TAXONOMICAL STUDIES ON SPIRAL NEMATODES OF FORAGE CROPS IN AND AROUND JHANSI DISTRICT.

THESIS

Submitted to the

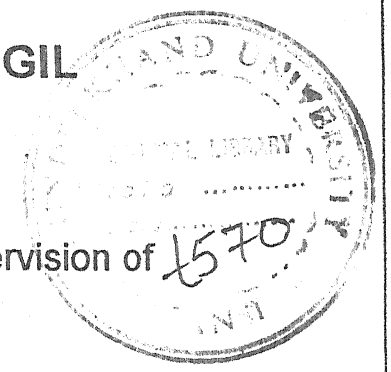
BUNDELKHAND UNIVERSITY

for the

DEGREE OF DOCTOR OF PHILOSOPHY IN ZOOLOGY

by

VIDYOTTAMA MUDGIL



Under the guidance and Supervision of

Dr. M.I. Azmi

Principal Scientist,

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SUPERVISOR'S CERTIFICATE

This is to certify that this work entitled **"Taxonomical studies of spiral nematode of forage crops in and around Jhansi District"** is an original piece of research work done by Vidyottama Mudgil M.Sc. (Zoology) under my guidance for the degree of Doctor of Philosophy (Zoology) of the Bundelkhand University, Jhansi (U.P.) India.

I further certify that :

(1) The thesis has been duly completed.

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(3) The thesis fulfils the requirements for the Ph. D. degree of the University.

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It is also certified that the candidate fulfils the requirements of attendance.

Director :

(P. S. Pathak)

Supervisor

(M.I. Azmi)

DECLARATION

I here by declare that the thesis entitled **"Taxonomical studies of spiral Nematode of forage crops in and around Jhansi District,"** being submitted for the degree of Doctor of Philosophy (Zoology) of the Bundelkhand University, Jhansi (U.P.) India is an original research work carried out by me and no part of this work has been submitted for any degree or any other academic qualifications at any other University.

Vidyottama Mudgil

Vidyottama Mudgil

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Vidyottama Mudgil

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CONTENTS

INTRODUCTION

Introduction

The term nema (for nematoda) and nematodes were introduced by Cobb (1932) and Chitwood, (1957).Nematodes are the lower invertebrates belonging to the order Nematoda as given by Diesing (1861) later on Nema ta was proposed as phylum and Nematoda as class by Maggenti (1981,1982) and Goodey(1963). They are of highly diversified group, they are found in almost all biotypes of the ecosystem and occur in unimaginable numbers in wide variety of shapes, sizes and structures. The plant parasitic nematodes are of considerable agricultural importance as pests of crop plant. They are minute ranging from 0.5 to 0.1 mm. Although nematodes of different kinds are fairly uniform structurally except for the differences in their cuticular structure lip region, feeding apparatus, oesophagus, excretory system and reproductive system etc.

Microscopic size of plant parasitic nematodes causes difficulty in identification of species. The first step for the identification of nematodes is an in-depth knowledge of the structure or morphology of these animals and the interpretation of these structures as diagnostic characters for differentiating taxa. No applied or experimental work is possible without correct identity of the species. Though species are characterized on the basis of morphology, genetics, embryology,

ecology, ethology, physiology, serology etc, but for all practical purpose the present day taxonomy depends almost exclusively on morphology. The morphological characters, both external and internal, can be studied and recorded with comparative case because of the transparent bodies of nematodes, in live or dead animals, under conventional Light Microscope (LM) or Scanning Electron Microscope (SEM) and Transmission Electron Microscopic (TEM).

A nematode can be defined in one sentence as "triploblastic, bilaterally symmetrical, unsegmented, pseudocoelomate animal". The nematodes, in general possess elongate, cylindrical or worm-like body, usually unciliated . Either the entire organism or some organs showing cell consistancy, are strictly determined in structure and shape and entirely unable to regenerate. The body is covered by tough and resistant cuticle secreted by epidermal (hypodermal) cells.

Spiral nematodes (*ch. Helicotylenchus spp.*) are ectoparasites of roots but may occur in the cortical tissues. (*H. multicinctus*) although not migrating through the cortex. *H.multicinctus* is an important parasite of banana throughout the banana growing areas of the world. The nematode reproduces by amphimixis and is known to survive without host plant for 4 months. *H. dihystera* is a cosmopolitan and polyphagous species (Siddiqi, 1972) and can survive for several months

in soil without host plants. Olive seedlings inoculated with 1,000 *H.dihystera* showed 78% reduction in top weight after 6 months and retardation in the development of the lateral roots (Diab & El Eraki, 1968) when associated with wilt bacterium. On inoculated sugar cane seedlings, *H.dihystera* completed its cycle in 35-37 days at 23-33° C (Rao & Swarup, 1976). It is also associated with forage crops (Azmi, 1978) and comes considerable damage (Azmi,1981). According to Nichola's (1975), only those nematodes which have close adaptive morphological and physiological associations with host plants should be called parasitic. A parasite has a physiological association with its host and completely depends on it for food, water and other physiological requirements.

The body of spiral nematodes assume spiral shape when relaxed with gentle heat, it curves ventrally. The shape of spiral formed is also variable. Spiral nematodes move slowly in soil, water or plant tissue, and unlike predatory and bacterial feeding forms, they do not jerk or twitch their head end or body. Their movement may be random or oriented towards the source of a stimulus. They are pseudocoelomate animal covered with a cuticular exoskeleton secreted by the hypodermis (-epidermis). They have longitudinal muscles for locomotion. These group of nematodes can be characterized by a terminal oral opening

surrounded by lips a protrusible stomatostylet with the stylet knobs orifice of the dorsal oesophageal gland opens near its base. A cirum-oesophageal nerve ring, an excretory system with a single duct and a pore like anus directed outward in the posterior region, a true tail (postanal continuation of the body) and they lack a circulatory system and motile cilia. Azmi and Jairajpuri (1978) studied the morphometric and allometric variations of *H. Indicus.* Firoza and Maqbool (1994) proposed a diagnostic compendium of the genus *Helicotylenchus* Steiner, 1945.

HISTORICAL REVIEW

Historical Review

Systematic position of the spiral nematodes

Kingdom	Animalia
Phylum	Nematoda
Class	Secernentia
Sub class	Tylenchida
Order	Tylenchida
Sub order	Tylenchina
Super family	Hoplolaimoidea
Family	Hoplolaimidae
Sub family	Rotylenchoidinae
Genus	*Helicotylenchus*

Helicotylenchus Steiner, 1945

Diagnosis :

Lip region without longitudinal striations. Dorsal oesophageal gland opening usually 1/4 or more of spear length behind the basal knobs of spear. Oesophageal glands are distinct, overlapping the intestine dorsally, laterally and ventrally, the largest overlap being ventral. Gonads amphidelphic, female tail usually curved dorsally, terminus conoid to hemispheroid, often mucronate. Phasmids

small, near anus.

Type species : *Helicotylenchus dihystera* (Cobb 1893) Sher,1961.

Filipjev (1934) proposed Hoplolaiminae and the genus *Rotylenchus* and listed only the type species *Tylenchus robustus* de Man, 1880. However,it was only in 1936 that he provided the diagnosis of the genus *Rotylenchus* there by establishing it in accordance with International Code of Zoological Nomenclature. Filipjev and Schuurmans Stekhoven (1941) expanded the diagnosis of the genus and included under it ten nominal species, all of which except the type have now been transferred to six other genera of Tylenchida (Baker,1962).

Steiner (1945) proposed the genus *Helicotylenchus* in the subfamily Tylenchinae and distinguished it from *Rotylenchus* on the basis of protruding oesophageal gland and preanal phasmids in the new genus and the oesophageal glands enclosed in terminal bulb and phasmids postanal in *Rotylenchus*.

Thorne (1949) gave an amended diagnosis of *Rotylenchus* and pointed out that *Tylenchus robustus* de Man, 1880 did have over-lapping oesophageal glands, the character that was used by Steiner to seperate *Helicotylenchus* from *Rotylenchus*. However, he did not

synonymise *Helicotylenchus* with *Rotylenchus*. The diagnosis of the subfamily Hoplolaiminae was emended and the following genera were included *Hoplolaimus, Rotylenchus* and *Helicotylenchus*.

Goodey (1951) doubted the validity of *Helicotylenchus* and regarded it possible synonym of *Rotylenchus*, but retained both these genera in Hoplolaiminae. It was Wieser who in 1953 elevated the sub-family Hoplolaiminae to Hoplolaimidae.

Golden (1956) separated the two genera *Rotylenchus* and *Helicotylenchus* on the basis of the differences in the position of their phasmids and the orifice of the dorsal oesophageal gland phasmids preanal, and the opening of dorsal oesophageal gland more than one-third of the spear length from base of spear in *Helicotylenchus* phasmids, postanal and the opening of dorsal oesophageal gland less than one-third of the spear length from base of spear in *Rotylenchus*.

Andrassy (1958) revised Hoplolaiminae and recognized two groups under this subfamily, one group comparising of *Rotylenchus, Helicotylenchus* and a new genus *Gottholdsteineria* having phasmids pore-like and the other group with *Hoplolaimus, Scutellonema* having large scutella-like phasmids.

Chitwood (1958) proposed the subfamily Hoplolaiminae under Hoplolaimidae. Perry, Darling, and Throne (1959) revised the genus

Helicotylenchus, and synonymised *Gottholdsteineria* with *Helicotylenchus*. Skarbilovich (1959) recognized the genera *Hoplolaimus*, *Rotylenchus* and *Helicotylenchus* in the subfamily Hoplolaiminae, under the family Tylenchidae. Hopper and Cairns (1959) accepted the family *Hoplolaimidae*, and the genera *Rotylenchus* and *Helicotylenchus* were placed under Hoplolaiminae.

Thorne (1961) recognized the genera *Rotylenchus* and *Helicotylenchus* under *Hoplolaiminae*, but placed them under Tylenchidae. Sher (1961-66) in a series of papers gave an excellent account of Hoplolaiminae, its nominal genera and species and also proposed some new genera and a number of new species. He also recognized the familly Hoplolaimidae. Paramonov (1962) recognized the subfamily Hoplolaiminae under Hoplolaimidae the genera *Helicotylenchus* and *Rotylenchus* were assigned to the subfamily Hoplolaiminae. Baker (1962) accepted only the genera *Rotylenchus* and *Helicotylenchus* in the subfamily Hoplolaiminae. Goodey (1963) recognized the subfamily Hoplolaiminae and included the genera *Rotylenchus* and *Helicotylenchus* under it Allen and Sher (1967) accepted the genera *Helicotylenchus* and *Rotylenchus* in Hoplolaiminae but placed it under Tylenchidae. Paramonov (1967) accepted both Hoplolaimidae and Hoplolaiminae. Further he grouped

these under the superfamily Hoplolaimoidea. Kirjanova and Krall(1969) considered the genera *Rotylenchus* and *Helicotylenchus* in Hoplolaiminae. Hooper (1969) partly followed the classification as given by Allen and Sher (1967), but recognized the family Hoplolaimidae.

Siddiqi (1970) revised the classification of Hoplolaimidae and recognized subfamily Hoplolaiminae and Rotylenchoidinae under it. He placed the genus. *Rotylenchus* in Hoplolaiminae; and *Helicotylenchus* in Rotylenchoidinae. Siddiqi (1971) proposed the synonymy of Hoplolaimoidea with Tylenchoidea. Golden (1971) has placed the genera *Helicotylenchus* and *Rotylenchus* under the subfamily Rotylenchinae of the family Hoplolaimidae.

GROSS MORPHOLOGY

Gross morphology

The word nematode is of Greek origin (*nema-thread and eidos* - form), so they are thread like popularly known as thread worms. They are also known as eelworms because of their serpentine eel-like body and round worms due to their body being circular in a cross section. They possess a typically cylindroid a vermiform body. The principal axis of the body is longitudinal and the widest diameter lies mostly near mid-body from where it tapers towards extremities (fusiform).

Body posture :

Species of the genus *Helicotylenchus* generally assume spiral shapes when relaxed by gentle heating. The curvature of the body is always towards ventral side.

Size and shape :

The size of the body of species of *Helicotylenchus* varies from while 0.46 to 0.68 mm. (Sher,1966)

Cuticle :

The cutile is secreted by the epidermal cells that are derived from the ectoderm. It is a non-cellular, non living layer forming the external

covering of the nematode. It is tough but elastic and serves as an exoskeleton protecting the inner soft tissue of the body by acting as a barrier to undesirable elements in the environment. The cuticle on the outer side of the body is called external cuticle and those lining the internal structures as internal cuticle. It regulates permeability and turgor pressure in the body. The cuticle of *Helicotylenchus* is marked with fine striations. There are four incisures in the lateral fields. The width of lateral lines near oesophagus and mid body is some what uniform, where as in the region of the phasmids it is variable out line with annules.

Hemizonid, excretory pore and nerve ring :

The hemizonid (-belt or girdle) is a highly refractive, biconvex structure forming a semicircle ventrally and ending at the lateral fields. It is present either anterior or posterior to the excretory pore. The hemizonid represents a ventro-lateral (or subventral) commissure that connects the nerve ring to the ventral nerve cord and is located between the cuticle and the hypodermis. On the ventral side of the body, the hemizonid and excretory pore are clearly visible.

The nerve ring is situated along the isthmus between the median bulb and basal glandular portion of the oesophagus.

Phasmids:

The phasmids are lateral sense organs, occur in a pair, usually one on each side of tail through they are small often insignificant structures. They are of taxonomic importance . The phasmids are sometimes preanal or sometimes post anal. The usual location of phasmids is in the centre of the lateral fields almost at the same latitude on either side of the tail. They open to the exterior through a minute pore. The position of phasmids and their external appearance are important taxonomic characters at species and generic levels. Their position in relation to anus is an important taxonomic characters small in the vicinity of the level of the anus.

Mouth parts :

Lip Region : The lip region (also called as head) shows many important variations, which may be used either as specific or generic characters. In some nematodes the lip region is completely merged with the body. The head region continuous or slightly set off from the body. The head is either marked with transverse straitions. Which may be distinctly or indistinctly visible. The shape of lip region is variable, may be truncate, hemispherical or rounded.

Spear :

The spear also called as mouth cavity or buccal cavity forms the

feeding appratus connecting the mouth with the oesophagus. It is exceedingly variable in shape, size and detailed structure and is considered an extremely valuable and handy character in nematode taxonomy.

The spear is made up of two parts. The anterior part called chelilostome is formed by an invagination of the external cuticle and is not surrounded by oesophageal tissue. The posterior part formed by the anterior region of oesophagus lies embedded in the oesophageal tissue is termed as oesophagostome. Both these sections of stoma are heavily cuticularized and their structure provides a clue to the feeding habit of the animal. In *Helicotylenchus* it is a well-developed structure of an anterior conical (metenchium) and a posteriorly cylindrical (telenchium) portions which are clearly demarcated. The ratio between anterior conical and post cylendrical part is not always consistent. The spear knobs vary in shape from rounded to slightly anteriorly directed or with slopping to flattish anterior surface

Oesophagous :

Oesophagous is the second and largest part of stomodeum lying between stoma and Intestine The term pharynx instead of oesophagus is perhaps more appropriate from the point of view of comparative

morphology but the letter has gained general acceptance due to usage over along period of time and hence is being used here. The oesophagus is chiefly a 'food transporter' pumping food from the low pressure stoma to the high pressure Intestine. It provides very useful information on the phylogenetic relationships of nematodes and is thus can a reliable and important taxonomic characters at all levels of classification but more so at higher levels. Oesophagus typical hyplolaimoid type, represented by a procarpus, a median bulb and a basal glandular portion., The procarpus is cylindrical, and the median bulb having a strongly sclerotized valvular appratus. The basal glandular portion of the oesophagus overlaps the Intestine dorsally, laterally and ventrally, the largest overlap being ventral. The three oesophageal glands are uninucleate. The distance between the base of oesophageal gland lobe and the oesophago-lintestinal junction is of taxonomic importance. The intestine is tubular, intestinal cells are granular. It leads to rectum which opens out side through the anus on the ventral side of the posterior region of the body.

Rectum Anus :

The intestine opens in to rectum which inturns open out side by a slit called anus.

Tail:

Among the invertebrates, the tail is unique to nematodes. This post-anal elongation of the body is present in all stages of nematodes, i.e., in adult (male and female) and juveniles or larvae. There are innumerable types of tail, varying in size and shape, usually similar in the two sexes, but some time slightly to strikly different. In some species, the intestine may extend in to the tail forming a blind sac a feature unknown in any other animal group; vertebrate or invertebrate.

The tail and its associated structures irrespective of their utility to the animal, not only provide very useful characters to the taxonomist but also make it easier for the non-taxonomist to recognize a nematode species even at lower magnifications.

In *Rotylenchus* and many species of *Helicotylenchus* the tail is short bluntly conoid to obtusely rounded. A digitate type of tail is present in some species of *Helicotylenchus*. The size and shape of tail is variable. It may be dorsally curved and provided with slight ventral projection to hemispherical and smooth. The ventral projection may be pointed or irregularly indented.

Reproductive system :

The nematodes are dioecious or amphigonus with separate males

and females with in a species. However, there are only a few species having males and females found in equal proportions. Usually the males and lesser or far lesser than the females or may even be completely absent.

This phenomenon is of hermaphoroditism where both sperm and ova are simultaneously produced by different part of the same gonad are common in these nematodes. The sperm producing organ is here termed spermagonium. This phenomenon was reported to occur in species of *Helicotylenchus*, *Rotylenchus* etc. but is doubled by many works. As a result of hermaphroditism the progeny that is produced has less variable genetic constitution and is not able to successfully with stand fluctuating environmental conditions. In parthenogenesis the males are almost completely laking and the eggs can develop without fertilization.

The male are generally slightly smaller than their females and lie upon death with their posteriors and curved ventrally because of the strong copulatory musculature . The two sexes can also be easily separated on the basis of their primary and secondary sexual characters.

The reproductive system is composed of two tubular gonads which very in length and may be straight. There are two most of germ cells proliferation.

i- Telogonic : the germ cells are proliferated only at the apical and or tip of the gonad.

ii- Hologenic : the germ cells are produced along the entire length of the gonid.

The genital tubes are lined with a single layer of epithelium which covers the germ cells and forms the ducts. In males the terminal reproductive duct joins the rectum to form cloaca.

Female Reproductive system :

The female nematodes of *Helicotylenchus* spp. possess two sets or branches (didlephic) reproductive organs. The number and the manner of arrangement of sexual branches is considered to be of great taxonomic value. When to branches are present these are on the opposite sides of vulva (amphidelphic) i.e., one branch anterior to vulva and the other posterior to vulva. The position of vulva is usually in or near the middle of body. The various stages in the reduction and loss of gonad can be seen in species of *Helicotylenchus*, *Rotylenchoides.*

A female sexual branch typically comparises an ovary, oviduct, uterus, vagina and vulva. The ovary is a hollow, elongate tube lined with flattened epithelial cells and contains few to a large number of oocytes. The apical end of ovary has a cap cell at the tip. The oocytes

as and when they are ripe pass into the oviduct through a tiny canal formed by the oviduct cells. It is believed that the contraction of the somatic musculature during locomotion helps in the oocyte transport. The oviduct is made up of high columnar epithelial cells.

The structure number and arrangement of these cells is of fundamental importance in nematode systematics. The uterus is the largest and the most complex part of the reproductive tract and serves the function of fertilization egg shell formation and ejection of egg (egg laying). The upper distal part of the uterus is differentiated into a sperm storage organ (spermatheca). It keeps the sperms in a viable state. The size and shape (rounded, oval, elongated) of spermatheca may differ from species to species or organs to organs and is of some taxonomic importance. It may be axial or non-axial (offset). The spermatheca is bisexual species is usually full of sperm is mature female, in parthenogenetic females it is present though small and empty.

The uterus (or uteri) join vagina which is a short, narrow and flattened tube lined with cuticle and provided with well-developed musculature(dilator and constrictor vagina).

The egg in nematodes are laid out side the body (oviparous) where the embryonic development takes place (exotoky). However, sometimes the egg develop within the body of female (endotoky) without being laid.

MATERIAL AND METHODS

JHANSI (U.P.)

[Latitude - 25.26 N
Longitude - 78.35E]

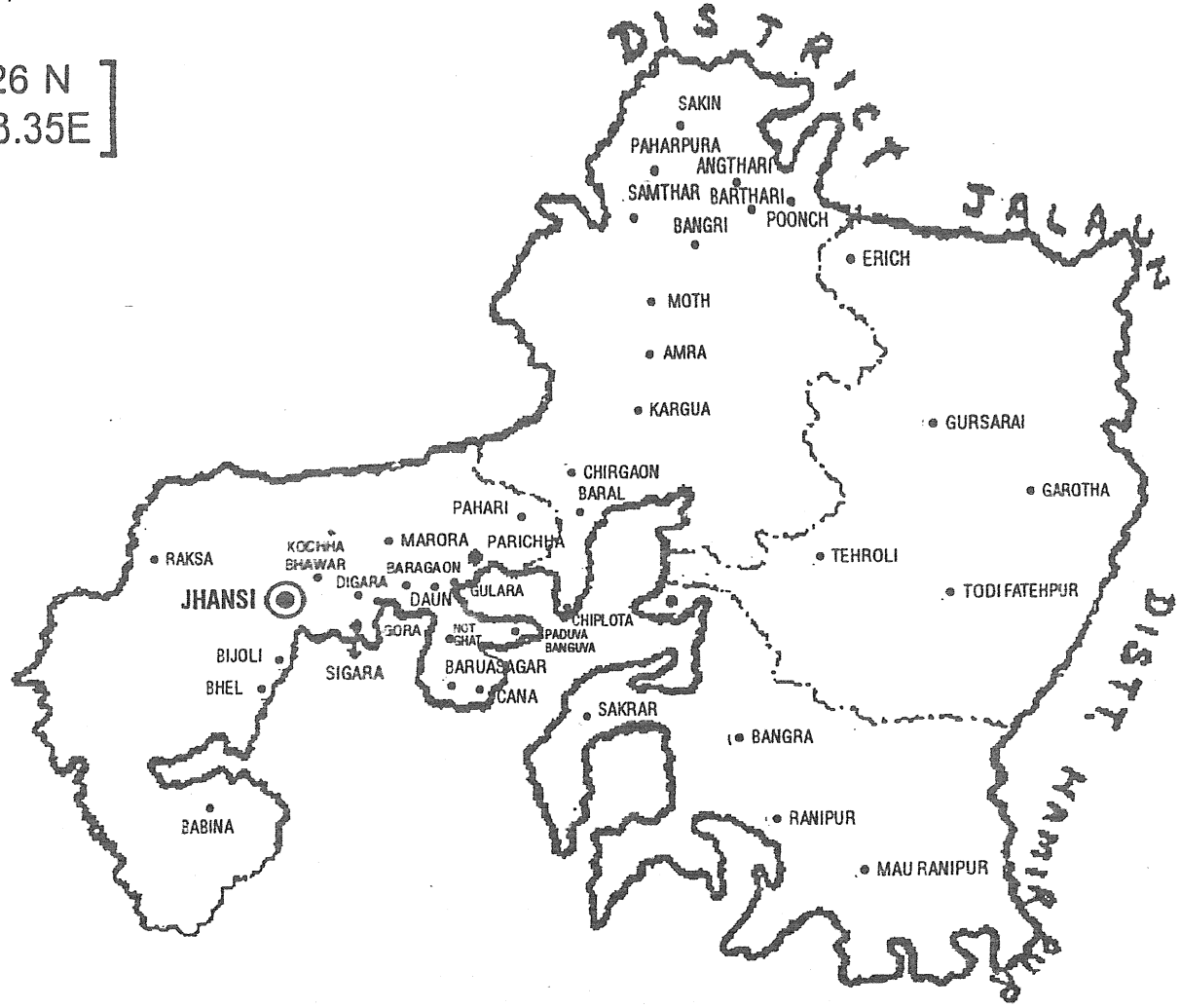

Fig. 1. Map of the area surveyed in and around Jhansi (U.P.) - India

Material and Methods

A survey of the spiral nematode belonging to the genus *Helicotylenchus* has been conducted from forage crop growing areas in and around Jhansi following localities has been covered fig....1.....

1.	Antheri	Dist. Jhansi U.P
2.	Babina	"
3.	Bangroli	"
4.	Baragoan	"
5.	Barata	"
6.	Baral	"
7.	Baruasagar	"
8.	Barthari	"
9.	Bhel	"
10.	Bijoli	"
11.	Canna	"
12.	Chirgaon	"
13.	Chiplota	"
14.	Daun	"

15. Digara "

16. Gora "

17. Gulara "

18. Jhansi "

19. Kargua "

20. Kochabhanwar "

21. Laxmanpura "

22. Marora "

23. Moth "

24. Mozapharpura "

25. NotGhat "

26. Old barata "

27. Paduva Banguva "

28. Parichha "

29. Pahari "

30. Paharpura "

31. Raksa "

32. Samthar "

33. Sigara "

34. Sujata Mota "

The soil samples were collected from the most important forage crops :

Anjan grass	*Cenchrus ciliaris*
Berseem	*Trifolium alexandrinum*
Barley	*Hordeum vulgare*
Bermuda grass (Doob)	*Cynodon dactylon*
Bothriochloa	*Bothriochloa intermedia*
Cowpea (lobia)	*Vigna unguiculata*
Crysopogan	*Crysopogan sp*
Dhaman grass (moda)	*Cenchrus setigerus*
Dicanthium grass(marvel)	*Dicanthium annulatum*
Dolicus (lab-lab bean)	*Lablab purpureus*
Gui nea grass	*Panicum maximum*
Lucerne	*Medicago sativa*
Machuri grass	*Iseilema laxum*
Maize	*Zea mays*
Napier grass	*Pennisetum purpureum*
Oat	*Avena sativa*
Dinanath grass	*Pennisetum pedicellatum*
Setaria	*Setaria sphacelata*
Sorghum (Jowar)	*Sorghum bicolor*
Subabool	*Leucaena leucocephala*
Soyabean	*Glycine max*

Soil Sampling :

The soil samples were collected from around the roots of forage crops from various localities in and around Jhansi India. Soil from the rhizosphere is collected after removing the top 3 to 5 cm of soil and litter layer at a depth of 15-20 cm. The samples were stored in polythene begs and were properly labelled. The analysis and processing of the samples was done in the laboratory in the following manner.

Processing of samples :

The samples were processed by sieving and decantation techniques. Approximately 500 ml of soil was taken in a bucket filled to two-third of its volume with water and stirred gently so as to get a homogeneous suspension. The suspension was left undisturbed for about 15-20 seconds. This allows heavy soil particles to settle down at the bottom of the bucket, while the nematodes along with fine soil particles remain in the suspension. The whole of suspension was passed through a coarse sieve in order to separate undesirable stones leaves etc. This comparatively homogeneous mudy suspension was collected in another bucket and passed through a set of two sieves of 150 and 300 mesh numbers (Pore size 104 and 53 micorns, respectively). Most

of the soil particles pass through the sieves while the nematodes along with same debris etc. were retained on the sieves and collected in a beaker.

Isolation :

The suspension containing the nematodes was them filtered through a modified Baerman's funnel (White head & Hemming, 1965). After 24 hours, the filtered suspension containing nematodes was collected in a test tube.

Killing and fixation :

The nematodes were concentrated by placing the suspension in a test tube for about 2-3 hours. The undesired amount of water was removed with the help of a dropper . The nematodes were killed and fixed by using hot (60-65^0 C) 8% formalin (double strength). The hot formalin was poured in the test tube containing the nematode suspension in a small quantity of water. The nematodes fixed as above may be stored indefinitely in this medium.

Mounting and sealing :

Nematodes were picked up with the help of a needle and transferred to cavity blocks containing a mixture of glycerine alcohol

(5 parts glycerine and 95 parts of 30% alcohol) The blocks were than kept in a dessicator at room temperature for gradual dehydration. After 2-3 weeks, the nematodes were ready for preparing permanent mounts in dehydrated glycerine. Pieces of glass-wool of suitable thickness were placed between the slide cover slips to prevent flattening of the specimens or paraffin wax of 60-65^0 C melting point is placed as three lumps around the drop, each lump about the size of the drop or a little larger, and the cover slip is placed on the wax lumps. The slide is then heated on a hot plate or over a flame . Just enough to melt the wax which spreads and fills the space between the slide and cover slip holding the nematodes in mountant in the centre. The coverslips were sealed with natural colour (mercury free) nail polish. Temporary mounts were also prepared whenever desired in water or 4%. formalin and were sealed with a mixture of 50% wax and 50% vaseline.

Measurements and drawings :

The measurements of the specimens (mounted in dehydrated glycerine) were taken with the help of an ocular micrometer. De Man's (1884) formula for representing the dimensions of the nematodes was used. All the illustrations were made with the help of camera lucida.

LIST OF ABBREVIATIONS

List of Abbreviations

Since the morphological characters are the basis for the differential diagnoses of the various genera and higher categories and that they will continue to be the basis for identification and systematics it is important to examine them in some detail and to remain aware of the developments that take place in the observation, identification and interpretation of these characters.

Morphometry and Allometry :

De Man's (1884) proposed the following formula of body ratios for nematodes measurements.

L= body length

MBW =maximum body width

$$a = \frac{\text{body length}}{\text{mbw}}$$

$$b = \frac{\text{body length}}{\text{oesophageal length}}$$

$$c = \frac{\text{body length}}{\text{tail length}}$$

These ratios are widely used in the description of new species of nematodes today although they vary greatly within species other ratios and symbols include the following :

$$V = \frac{\text{distance from head end to vulva}}{\text{body length}} \times 100$$

$$b' = \frac{\text{body length}}{\text{distance from head end to posterior end of oesophageal gland}}$$

$$c' = \frac{\text{tail length}}{\text{body width at anus}}$$

m = length of conus as percentage of total stylet length.

o = distance between stylet base and orifice of dorsal oesophageal gland as percentage of stylet length.

µm = micron.

List of Nominal Species
Helicotylenchus of the World

(The species recorded in India are marked with *)

1. *Helicotylenchus abunami* Siddiqi , 1972
2. *H. acutus* Teben 'Kova' , 1983
3. *H. aerolatus* Van den Berg & Heyns, 1975
4. *H. africanus* (Micoletzky, 1916) Andrassy, 1958
5. *H. agrostus n.sp*
6. *H. agricola* Elmiligy , 1970
7. *H. angularis* Mulk & Siddiqi, 1982
8. *H. anhelicus* Sher, 1966
9. *H. annobonensis* (Gadea, 1960) Siddiqi, 1972
10. *H. aquili* Khan & Nanjappa,1972
11. *H. arachisi* Mulk & Jairajpuri, 1975
12. *H. astriatus* Khan & Nanjappa, 1972
13. *H. australis* Siddiqi , 1972
14. *H. bambesae* Elmiligy, 1970
15. *H. belli* Sher, 1966
16. *H. belurensis* Singh & Khera, 1980
17. *H. bihari* Mulk & Jairajpuri, 1975
18. *H. borinquensis* Roman, 1965

19. *H. bradys* Thorne & Malek, 1968

20. *H. caipora* Monteiro & Mendonca, 1972

21. *H. californicus* Sher, 1966

22. *H. canadensis* Waseem, 1961*

23. *H. canalis* Sher, 1966

24. *H. caribensis* Roman, 1965*

25. *H. carolinensis* Sher, 1966

26. *H. cavenessi* Sher, 1966

27. *H. clarkei* Sher, 1966

28. *H. concavus* Roman, 1961

29. *H. conicephalus* Sher, 1966

30. *H. coomansi* Ali & Loof , 1975

31. *H. cornurus* Anderson, 1974

32. *H. craigi* Knobloch & Laughlin , 1973

33. *H. crassatus* Anderson, 1973

34. *H. crenacauda* Sher, 1966

35. *H. curvatus* Roman, 1965

36. *H. delhiensis* Khan & Nanjappa , 1972

37. *H. densibullatus* Siddiqi, 1972

38. *H.depressus* Yeast, 1967

39. *H. digitatus* Siddiqi & Husain, 1964*

40. *H. digitiformis* Ivanova, 1967

41. *H. digonicus* Perry in Perry, Darling & Thorne, 1959*

42. *H. dihystera* (Cobb, 1890) Sher, 1961

43. *H. dolichodoryphorus* Sher, 1966

44. *H. egyptiensis* Tarjan, 1964*

45. *H. elegans* Roman, 1965

46. *H. erythrinae* (Zimmermann, 1904) Golden, 1956*

47. *H. exallus* Sher, 1966

48. *H. flatus* Roman, 1965

49. *H. girus* Saha, Chawla & Khan,1974

50. *H. glissus* Thorne & Malek, 1968

51. *H. goodi* Tikyani, Khera & Bhatnagar, 1969

52. *H. graminophilus* Fotedar & Mahajan, 1974

53. *H. gratus* Patil & Khan, 1983

54. *H. haki* Fotedar & Mahajan, 1974

55. *H. hazratbalensis* Fotedar & Handoo, 1974

56. *H. hoplocaudus* Mangredar, 1972

57. *H. hyelrophilus* Sher, 1966

58. *H. imperialis* Rashid & Khan, 1974

59. *H. incisus* Darekar & Khan, 1979

60. *H. indenticaudatus* Mulk & Jairajpuri , 1975

61. *H. indicus* Siddiqi, 1963*

62. *H. insignis* Khan & Basir, 1964

63. *H. jammuensis* Fotedar & Mahajan, 1974

64. *H. jojultensis* Zavaleta - Mejia & SoSa Moss, 1979

65. *H. kashmirensis* Fotedar & Handoo, 1974

66. *H. krugeri* Van den Berg & Heynns, 1975

67. *H. labiatus* Rroman, 1965

68. *H. labiodiscinus* Sher, 1966*

69. *H. leiocephalus* Sher, 1966

70. *H. longicaudatus* Sher, 1966

71. *H. macronatus* Mulk & Jairajpuri, 1975

72. *H. magniferensis* Elmigly, 1970

73. *H. martini* Sher, 1966

74. *H. microcephalus* Sher, 1966

75. *H. microdorus* Prasad, Khan & Chawla, 1965*

76. *H. minzi* Sher,1966

77. *H. multicinctus* (Cobb, 1893) Golden, 1956*

78. *H. mucronatus* Siddiqi,1963

79. *H. neopaxilli* Inserra, vovlas & Golden,1979

80. *H. nigliensis* Sher, 1966

81. *H. obtusicaudatus* Darekar & Khan, 1979

82. *H. oleae* Inserra, vovals & Golden, 1979

83. *H. orientalis* Sagitov, Sanpedro, Santos & Paneke, 1978

84. *H. orthosomaticus* Siddiqi, 1972

85. *H. oscephalus* Anderson, 1979

86. *H. paracanalis* Sauer & Winoto, 1975

87. *H. paradihysteroides* Darekar & Khan, 1979

88. *H. paragirus* Saha, Chawla & Khan, 1974

89 *H. paraplatyurus* Siddiqi, 1972

90. *H. pasohi* Sauer & Winoto, 1975

91. *H. paxilli* Yuen, 1964

92. *H. persici* Saxena, Chhabra & Joshi, 1972

93. *H. phalerus* Anderson, 1974

94. *H. pisi* Swarup & Sethi, 1968*

95. *H. plumariae* Khan & Basir,1964

96. *H. pseudodiagonicus* Szezygil, 1970

97. *H. pseudorobustus* (Steiner, 1914) Golden,1956*

98. *H. pteracereus* Singh, 1971*

99. *H. retusus* Siddiqi & Brown, 1964*

100. *H. reynosus* Razjivin,O'Relly & Milian,1973

101. *H. rotundicauda* Sher, 1966

102. *H. sacchari* Razjivin, et. al; 1973

103. *H. sandersae* Ali & Loof, 1975

104. *H. serenus* Siddiqi, 1963

105. *H. seshadrii* Singh & Khera, 1980

106. *H. sharafati* Mulk & Jairajpuri, 1975

107. *H. sieverii* Razjivin,1971

108. *H. solani* Rashid & Khan, 1971

109. *H. spitsbergensis* Loof, 1971

110. *H steineri* Fotedar & Mahajan, 1974

111. *H. stylocercus* Siddiqi & Pinochet, 1979

112. *H. teleductus* Anderson, 1974

113. *H. teres* Gaur & Prasad, 1972

114. *H. thornei* Roman, 1965*

115. *H. trifolus n.sp*

116. *H. trivandranus* Mohandas, 1976

117. *H. tropicus* Roman, 1965

118. *H. truncatus* Roman,1965

119. *H. tumidicaudatus* Phillips, 1971

120. *H. tunisiensis* Siddiqi, 1964

121. *H. urobelus* Anderson, 1978

122. *H. variabilis* Phillips, 1971

123. *H. varicaudatus* Yuen, 1964*

124. *H. ventroprojectus* Patil & Khan, 1983

125. *H. vulgaris* Yuen, 1964

126. *H. willmottae* Siddiqi, 1972

List of Synonims

1. *H. bakeri* Gupta & Chhabra, 1975 (=*H. thornei*)
2. *H. broadbalkiensis* Yuen, 1964 (=*H. digonicus*)
3. *H. cairnsi* Waseem, 1961 (=*H. canadensis*)
4. *H. crenatus* Das, 1960 (=*H. dihystera*)
5. *H. impar* Prasad et. al; 1965 (=*H. retusus*)
6. *H. indentatus* Chaturvedi & Khera, 1979 (=*H. crenacauda*)
7. *H. iperoiguensis* (Carvalho) Andrassy,1958 (=*H. multicinctus*)
8. *H. melancholicus* (Lordello) Andrassy, 1958 (=*H. erythrinae*)
9. *H. paracrenacauda* Phukan & Sanwal, 1981 (=*H. crenacauda*)
10. *H. pteracercus* Singh, 1971 (=*H. crenacauda*)
11. *H. pteracercusoides* Fotedar & Kaul, 1985 (=*H. crenacauda*)
12. *H. punicae* Swarup and Sethi, 1968 (=*H. dihystera*)
13. *H. regularis* Phillips, 1971 (=*H. exallus*)
14. *H. sagitovi* Fortuner Merny & Roux, 1981 (=*H. orientalis*)
15. *H. spicaudatus* Tarjan, 1964 (=*H. erythrinae*)
16. *H. teleductus* Anderson, 1974 (=*H. dihystera*)

Species Inquirendae

1. *H. acunae* Fernandez, Razjivin, Ortega & Quincosa, 1980
2. *H. acutucaudatus* Fernandez,Razjivin, Ortega & Quincosa, 1980
3. *H. altanticus* Fernandez, Razjivin, Ortega & Quincosa, 1980
4. *H. amplius* Anderson & Eveleigh, 1982
5. *H. apiculus* Roman, 1965
6. *H. bifurcatus* Fernandez, Razjivin, Ortega & Quincosa, 1980
7. *H. brassicae* Rashid, 1972
8. *H. caudatus* Sultan, 1985
9. *H. certus* Eroshenko & Nguen Vu Thanh ,1981
10. *H. coffae* Eroshenko & Nguen Vu Thanh, 1981
11. *H. conicus* Baydulova, 1981
12. *H crenatus* Das, 1960
13. *H. curvicaudatus* Fernandez, Razjivin, Ortega & Quincosa,1980
14. *H. dignus* Eroshenko & Nguen Vu Thanh, 1981
15. *H. dihysteroides* Siddiqi, 1972
16. *H. eletropicus* Darekar & Khan,1980
17. *H. fatcatus* Eroshenko & Nguen Vu Thanh, 1981
18. *H. ferus* Eroshenko & Nguen Vu Thanh, 1981
19. *H. goldeni* Sultan & Jairajpuri, 1979
20. *H. holguinensis* Sagitov,Sampedro,Santos & Paneke, 1978

21. *H. impar* Prasad, Khan & Chawla, 1965

22. *H. indentatus* Chaturvedi & Khera, 1979

23. *H. inifatis* Fernandez, Razjivin, Ortega & Quincosa, 1980

24. *H. interrogativus* Eroshenko, 1980

25. *H. issykkulensis* Sultan - alieva, 1983

26. *H. kherai* Kumar, 1982

27. *H. laevicaudatus* Eroshenko & Nguen Vu Thanh, 1981

28. *H leucernis* Khan & Ahmad, 1970

29. *H. lissocaudatus* Fernandez, Razjivin, Ortega & Quincosa, 1980

30. *H. lobus* Sher, 1966

31. *H. magnicephalus* Phukan & Sanwal, 1981

32. *H. microlobus* Perry in Perry, Darling & Thorne,1959

33. *H. monstruosus* Eroshenko, 1984

34. *H. montanus* Teben' Kova, 1983

35. *H. morasii* Darekar & Khan,1980

36. *H. mucrogaleatus* Fernandez,Razjivin,Ortega & Quincosa, 1980

37. *H. nannus* Steiner, 1945

38. *H. Neopaxilli Inserra et.al* , 1979

39. *H. nigeriansis* Sher, 1966

40. *H. notabilis* Eroshenko & Nguen Vu Thanh, 1981

41. *H. Oleae Inserra et.al*, 1979

42. *H. oryzae* Fernandez, Razjivin, Ortega & Quincosa, 1980

43. *H. Paraconcavus Schliephake et.al,* 1985

44. *H. paraptera cercus* Sultan,1981

45. *H. paraconcavus* Rashid & Khan, 1974

46. *H. playturus* Perry in Perry, Darling & Thorne, 1959

47. *H. pseudopaxilli* Fernandez Razjivin, Ortega & Quincosa, 1980

48. *H. punicae* Swarup, Sethi, 1968

49. *H. reversus* Sultan, 1985

50. *H. rohtangus* Jairajpuri & Baqri, 1973

51. *H. scoticus* Boag & Jairajpuri, 1985

52. *H. shakili* Sultan, 1981

53. *H. similis* Fernandez, Razjivin, Ortega & Quincosa, 1980

54. *H. sparsus* Fernandez ,Razjivin,Ortega & Quincosa, 1980

55. *H. subtropicalis* Fernandez, Razjivin, Ortega & Quincosa, 1980

56. *H. talonus* Siddiqi, 1972

57. *H. trapezoidicaudatus* Fotedar & Kaul, 1985

58. *H. unicus* Fernandez, Razjivin, Ortega & Quincosa, 1980

59. *H. ussuriensis* Eroshenko, 1981

60. *H. valecus* Sultan, 1981

61. *H. venrrcosus* Fernandez, Razjivin, Ortega & Quincosa, 1980

62. *H. wajihi* Sultan, 1981

KEY TO SPECIES OF HELICOTYLENCHUS

Key to species of Helicotylenchus

(Based on Female)

1. Tail hemispherical, sub-cylindroid or sub- conoid with a rounded terminus, lacking a ventral projection..... 2.

- Tail dorsally convex-conoid to a pointed terminus or with a slight to well developed ventral or terminal projection.....67.

2. Spermatheca functional (with sperm) .....3.
- Spermatheca non-functional (with sperm) .....16.

3. Lip region truncate .....4.
- Lip region rounded or hemispherical..... .....10.

4. Tail terminus not annulated; phasmids near middle of tail ....***martini*** Sher; 1966.

- Tail terminus annulated; phasmids close to anus or pre-anal.. ..... 5.

5. Lip region with 4-5 annules, lacking a distinct labial disc.. ..... 6.

- Lip region lacking annules, with a distinct labial disc.. ..... 8.

6. Spear 26-29 microns long; phasmids 2-4 annules anterior to anal level.....7.

- Spear 31-33 microns long; phasmids 12 annules anterior to anus. .....***jammuensis*** Fotedar & Mahajan, 1974.

7. Body length 0.68 mm-0.80 mm orifice of dorsal oesophageal gland 7-9 microns from base of spear knobs .....***minzi*** Sher, 1966

- Body length 0.48-0.59 mm; orifice of dorsal oesophageal gland

11-14 microns from base of spear knobs.....***imperialis*** Rashid & Khan, 1974.

8. Tail straight dorsally, tapering ventrally having an unstriated area .....***coomansi*** Ali & Loof, 1975.

- Tail dorsally convex, with striated terminus..... 9.

9. Lip region with a single faint transverse striation; spermatheca slightly offset.....***australis*** Siddiqi, 1972

- Lip region without a transverse striation; spermatheca not offset .....***variabilis*** Philips, 1971.

10. Phasmids 1-6 annules posterior to anal level ; m = 50-66 .....11.
- Phasmids 1-11 annules anterior to anal level; m = 42-55.....12.

11. Lip region truncate L => 0.5mm.....***clarkei*** Sher, 1966
- Lip region hemispherical L =< 0.5mm.....***tripholus*** n.sp.

12 Orifice of dorsal oesophageal gland 12 microns behind stylet; phasmids11 annules anterior to anal level..... ....***tumidicaudatus*** Philips, 1971.

- Orifice of dorsal oesophageal gland 6-10 microns behind stylet; phasmids 2-6 annules anterior to anal level.....13.

13. In males phasmids anterior to anal or cloacal opening.....14.

- In males phasmids close to cloacal opening ..... 15.

14. Male tail dorsally offset; body curved ventrally..... .....***sandersae*** Ali & Loof, 1971.

- Male tail dorsally not offset; body more curved ventraly .....***caipora*** Monteiro & Mendonca, 1972.

15. Spear 29-32 microns long; V= 57-64.....***anhelicus*** Sher, 1966.

Spear 22-26 microns long; V= 64-70.....
.....***multicinctus*** (cobb, 1893) Golden, 1956.

16. Lip region lacking annules or with indistinct annules..... 6.

- Lip region with indistinct annules..... 38.

17. Lip region truncate..... 18.

- Lip region rounded or hemispherical..... 26.

18. Inner incisures of lateral not fusing in posterior third of tail;spear 23-36 microns long..... 19.

- Inner incisures of lateral fields fusing in posterior third of tail; spear 20-22 microns long.....
.....***astriatus*** Khan & Nanjappa, 1972.

19. Spear more than 30 microns long ..... 20.

- Spear less than 30 microns long..... 21.

20. Head truncate; spear 30-32 microns long.....
..... ***oleae*** Inssera *et. al.*; 1979.

- Head trapezoid with sides slightly concave; spear 32-36 microns long .....***tunisiensis***, Siddiqi, 1963.

21. Labial disc conspicuous; spear knobs anteriorly flattened to concave..... 22.

- Labial disc inconspicuous; spear knobs slopping back wards.....***indicus*** Siddiqi, 1963.

22. Tail hemispherical; phasmids pre-anal .....
.....***goodi*** Tikyani *et. al.*; 1966.

- Tail not hemispherical; phasmids post- anal..... 23.

23. Lip region more conical.....***krugeri*** Berg & Heyns, 1975.

- Lip region not so conical..... 24.

24. Body length 0.48-0.68 mm; spear 23-27 microns long..... .....***labiodiscinus*** Sher, 1966

- Body length 0.71-0.98 mm; spear 27-30 microns long..... 25.

25. Lip region without annulations; phasmids near centre of tail, 7 annules posterior to anal level .....***belli*** Sher, 1966.

- Lip region with indistinct annulations; phasmids located 2-4 annules posterior to anal level ....***graminophilus*** Fotedar & Mahajan, 1974.

26. Spear 34 microns or longer ..... 27.

- Spear 32 microns or shorter..... 28.

27. Spear knobs rounded with slightly concave surface; phasmids 11-19 annules anterior to anus..... .....***orthosomaticus*** Siddiqi, 1972.

- Spear knobs indented anteriorly; phasmids up to 10 annules anterior to anus .....***kashmirensis*** Fotedar & Handoo, 1974

28. Spear 27-32 microns long; tail end more curved dorsally..... 29.

- Spear 26 microns or shorter; tail end rather symmetrical.....31.

29. Lip region with 4-5 very faint annules; spear knobs anteriorly cupped .....30.

- Lip region without annules; spear knobs with slightly indented anterior surface .....***paraconcavus*** Rashid & Khan, 1974.

30. Phasmids 1-10 annules anterior to anal level; tail annules narrower on distal end.....
.....***jojutlensis*** Zavaleta-Mejia & Sosa Moss, 1979

- Phasmids 11-18 annules anterior to anal level; tail annules uniform on distal end.....***concavus***.Roman, 1961

31 V= 61-64; Tail cylindrical ..... 32.

- V=60-65; tail with broadly rounded, striated terminus.....36.

32. Tail loger than anal body width with distinct striations.....
.....***retusus*** Siddiqi & Brrown, 1964.

- Tail shorter and indistinctly striated ..... 33.

33. Hemizonid distinct, just anterior to excretory pore; 'O' = less than 50..... 34.

- Hemizonid absent; O = more than 50..... 36.

34. 'O' = 34-48 hemizonid extending over one body annule..... 35.

- 'O'=40-48; hemizonid not extending over one body annule.....***incisus*** Darker & Khan, 1978.

35. Stylet length 23-25 microns.....***girus*** Saha *et. al.;* 1974.

- Stylet length 125-27 microns.....
..... ***gratus*** Patil & Khan, 1982

36. Annules near mid body more than 1 microns wide; 'O' = 61-67
.....***paragirus*** Saha *et .al.;* 1973.

- Annules near mid body less than 1 microns wide; 'O'=58-68.....***obtusicaudatus*** Darekar & Khan, 1978.

37. Spear 21-22 microns long .....
.....*arachisi* Mulk & Jairajpuri 1975.

- Spear 24-29 microns long..... 38.

38. Tail terminus striatsd; inner incisures of lateral fields fused on distal third of tail.....*cavenessi* Sher, 1966.

- Tail terminus usually not striated; inner incisures of lateral fields not fused on tail.....*leiocephalus* Sher, 1966.

39. Spear knobs rounded .....*sieversii* Razjivin, 1971.

- Spear knobs indented anteriorly..... 40.

40. Median oesophageal bulb spherical, filling the body cavity .....
.....*carolinicusis* Sher, 1966.

- Median oesophageal bulb oval not filling the body cavity..... 41.

41. Lip region distinctly truncate..... 42.

Lip region rounded or hemispherical..... 49.

42. Tail terminus with exceedingly fine striations ..... 43.

- Tail terminus not so .....44.

43. Spear 30-34 microns long .....*vulgaris* Yuen, 1964

- Spear 20-21 microns long ..... *bihari* Mulk & Jairajpuri 1974.

44. Spear 30-34 microns long..... 45.

- Spear 24-28 microns long ..... 46.

- Spear 20-22 microns long ..... ***truncatus***.Roman, 1965.

45. Spear knobs anteriorly directed; tail terminus conoid 20 annules..... ***haki*** Fotedar & Mahajan, 1974.

- Spear knobs flattened; tail terminus hemispherical, 6-12 annules..... ***canadiensis*** waseem, 1961.

46. Inner incisures of lateral fields fusing for a short distance on tail end ..... 47.

- Inner incisures of lateral fields not fusing on tail end..... 48.

47. Spear 25 microns long; phasmids at or posterior to anus..... ..... ***labiatus*** Roman, 1965.

- Spear 21 microns long; phasmids at the level of anus having an 'additional pore' located about 13 annules anterior to anus nom. nov..... ***teres*** Gaur & Prasad, 1973

48. Anterior cephalids smaller, 1-2 body annules posterior to 1 microns long basal ring; vagina cylinderical..... .....***digonicus*** Perry *et. al.;* 1959.

- Anterior cephalids larger, more anterior to 2 microns long basal ring; vagina pyriform.....***crassatus*** Anderson, 1973.

49. Tail terminus with a non-annulated section.....50.

- Tail terminus annulated ..... 52.

50. Inner incisures of lateral lines not fusing in the middle of tail; spermatheca offset..... 51.

- Inner incisures of lateral lines fusing in the middle of tail; spermatheca continuous..... ***aqulii*** Khan & Nanjappa, 1972.

51. Non-annulated section of tail terminus located dorsally..... ..... ***depressus*** Yeats,1967.

- Non-annulated section of tail terminus located ventrally ro terminally..... .....***rotundicauda*** Sher, 1966

52. Spear 18-21 microns long..... ***microdorus*** Prasad *et. al.;* 1965

- Spear 21 microns or longer..... 53.

53. Tail about one anal body width or longer..... 54.

- Tail less than one anal body width long.....65.

54. Spermatheca dorsally offset ..... 55.

- Spermatheca axial ..... 59.

55. Spear 22-27 microns long; annules on tail terminus not narrower than other tail annules..... 56.

- Spear 28-39 microns long; annules on tail terminus nit narrower than other tail annules.....58.

56. Phasmids opposite the anus; tail one anal body width long..... ..... ***steineri*** Fotedar.& Mahajan, 1974.

- Phasmids from 2 annules behind to 4 annules anterior to anus; tail more than one anal body width long..... 57.

57. Stylet knobs rounded; spear more than 24 microns long..... .....***paraplatyurus*** Siddiqi, 1972.

- Stylet knobs conspicuously indented; spear less than 25 microns long .....***seshadrii*** Singh & Khera, 1979.

58. Spear 28-34 microns long; knobs rounded or slightly indented anteriorly.....***platyurus*** Perry *et. al.*; 1959.

- Spear 36-38 microns long; knobs anteriorly pointed..... ....***rohtaangus*** Jairajpuri & Baqri, 1973.

59. Dorsal oesophageal gland duct more than 50 percent length of stylet..... 60.

- Dorsal oesophageal gland duct less than 51 percent length of stylet or unreported..... 63.

60. Subventral gland not lobed; posterior reproductive branch under developed ..... ***orientalis*** Siddiqi & Hussain, 1964.

- Subventral gland lobed; posterior reproductive branch well-developed..... 61.

61. Tail hemispherial, length less than anal body width..... .....***hoplocaudus*** Manjredar, 1972.

- Tail sub-cylindroid,length greater than anal body width..... ..... 62.

62. Cephalids distinct; excretory pore posterior to oesophago-intestinal valve.....***teleductus*** Anderson, 1975.

- Cephalids obscure, excretory pore anterior to oesophago-intestinal valve.....***willomottae*** Siddiqi, 1972.

63. Head skeleton thick, septum deeply depressed; head annules 6-8, distinct.....***oscephalus*** Anderson, 1975.

- Head skeleton moderate, septum not markedly depressed; head annules absent or less than 6.....64.

64. L=0.68- 0.78 mm;tail terminus rounded..... .....***serenus*** Siddiqi, 1963

- L= 0.79-1.08 mm; tail terminus usually truncate.....

.....*spitsbergensis* Loof, 1971.

65. Body annules about 2 microns wide; tail uniformly.....
.....*pseudodigonicus* Szczygil, 1970.

- Body annules about 1.5 microns wide; tail variable in shape.....
.....*varicaudatus* Yuen, 1964.

66. Ventral or terminal projection of tail absent or slightly developed (less than 2 annules long)..... 67.

- Ventral or terminal projection of tail well-developed (2or more annules long but not as long as anal body width)..... 78.

- Terminal projection of tail enormously developed.....
.....*annobonensis* Gadea, 1960, Siddiqi, 1972.

67. Spermatheca functional (with sperm)..... 68.

- Spermatheca non-functional (with out sperm)..... 69.

68. Male stylet length 18-21 microns long; spicules less than 23 microns long.....

69. Anterior surface of spear knobs sloping back wards..... 70.

- Anterior surface of spear knobs flat,indented and concave..... 74.

70. Lip region truncate..... 71

- Lip region rounded or hemispherical.....
..... *densibullatus* Siddiqi, 1972.

71. Phasmids 4-7 annules anterior to anal level; spear knobs rounded.....*agricola* Elmigly, 1970.

- Phasmids 4 annules posterior to 4 annules anterior to anal level;

spear knobs with slopping anterior surface.....72.

72. Lip region with indistinct annules spear > 25 um.....***agrostus*** n.sp
- Lip region with distinct annules spear < 25 um.....73.

73. Lip annules 4-5; spear 21-23 microns long. .... ***indicus*** Siddiqi, 1963.

- Lip annules 2-3; spear 24-25 microns long..... ..... ***sharafati*** Mulk & jairajpuri, 1974.

74. Phasmids over 5 annules anterior to anal level..... 75.

- Phasmids near anus or up to 5 annules anterior to anal level.....79.

75. Lip region truncate..... 76.

- Lip region rounded or hemispherical..... 77.

76. Tail with a short unstriated process; 'O'=52-60..... ..... ***insignis*** Khan & Basir, 1964.

- Tail with an unstriated peg; 'O'=37-40..... ..... ***plumariae*** Khan & Basir, 1964

77. Body length 0.41-0.48 mm .....***caribensis*** Roman, 1965.

- Body length over o.55 mm ..... 76.

78. Spear 25-28 microns long; 'O'=37-45. ....***dihystera*** Sher, 1890, Cobb, 1961
- Spear 23-25 microns long; 'O'= 46-52..... .....***paradihysteroides*** Darekar & Khan, 1978.

79. Lip region truncate..... 80.

- Lip region rounded or hemispherical..... 83.

80. Spear 22 microns long or less.....***curvatus*** Roman, 1965

- Spear more than 22 microns long;..... 81.

81. Tail terminus tapering to a slight projection.....
.....***hazratbalensis*** Fotedar & Handoo, 1974.

- Tail terminus with a pronounced projection..... 82.

82. Stylet length 25-26 microns long; tail projection terminal.....
.....***reynosus*** Razjivin *et. al.*; 1973.

- Stylet length 22-24 microns long; tail projection ventral.....
.....***sacchari*** Razjivin *et. al.*; 1973.

83. Lip region continuous with 4-5 distinct annules..... 84.

- Lip region slightly offset with 4-5 indistinct annules..... 85.

- Lip region markedly offset, angular.....
.....***angularis*** Mulk & Siddiqi, 1982.

84 Body length 0.43-0.45 mm.....***elegans*** Roman, 1965

- Body length o.52-0.63 mm .....***abunaami*** Siddiqi, 1972.

85. Terminal projection lobed.....
.....***macronatus*** Mulk & Jairajpuri, 1974.

- Terminal projection not lobed..... 86.

86. Spermatheca functional (with sperm)..... 87

- Spermatheca non-functional (without sperm)..... 102.

87. Lateral fields aerolated.....88.

- Lateral fields not aerolated..... 90.

88. Lateral fields with incomplete aerolation over entire body.....
.....***aerolatus*** Berg & Heyns, 1975.

- Lateral fields irregularly aerolated..... 89.

89. Lip region hemispherical; spear knobs rounded, spear more than 26 microns long .....
.....***africanus*** Micoletzky, 1916 Andrassy, 1958.

- Lip region truncate;spear knobs indented, spear less than 26 microns long .....***belurensis*** Singh & Khera, 1979.

90. Spear 34-38 microns long .....
.....***dolichodory phorus*** Sher, 1966

91. Lip region not annulated; phasmids near middle of tail.....92.

- Lip region annulated; phasmids near anal level or anterior..... 93.

92. Tail spiculat .....***thornei*** Roman,1965.

- Tail longer with a short unstriated process.....
.....***persici*** Saxena *et. al.*; 1972.

93. Annules on distal dorsal portion of tail not distinctly narrower than other tail annules.....94.

- Annules on distal portion of tail distinctly narrower than other tail annules.....99.

94. Tail projection elongate, usually ending in a mucro or point.....
..... 95.

- Tail projection short and blunt.....***exallus*** Sher, 1966

95. Tail terminus indented ..... 96.

- Tail terminus not indented..... 97.

96. Orifice of dorsal oesophgeal gland 7-10 microns posterior to stylet; tail with 7-13 annules ventrally (4-11 microns long)..... .....***urobelus*** Anderson, 1978.

- Orifice of dorsal oesophageal gland 11-14 microns posteriorto stylet; tail with 14-30 annules ventraly (11-16 microns long)..... .....***stylocercus*** Siddiqi & Pinochet, 1979.

97. 'O'= 35-37; phasmids 8-12 annules anterior to anal level..... .....***erythrinae*** Zimmermann, 1904 Golden,1956.

- 'O'=48-63; phasmids near anal latitude..... 98.

98. Stylet length 26-31 microns long; head with 5-6 annules, tail projection short, broadly rounded lacking a mucro..... .....***pasohi*** Sauer & winoto, 1975.

- Stylet length 21-23 microns; head with 4 annules; tail projection well developed, setoff bearing a mucro..... .....***mucronatus*** Siddiqi, 1963

99 Spear 24-27 microns long; tail projection usually with irregular outline .....100.

- Spear 28 microns or longer; tail projection usually with regular outline..... 101.

100. Tail terminus indented; spicules 28-30 microns long..... .....***cornurus*** Anderson, 1979.

- Tail terminus not indented; spicules 23-26 microns long.....

.....*californicus* Sher, 1966.

101. Phasmids not in centre of lateral field; C=0.6-0.9.....
.....*nigeriensis* Sher, 1966.

- Phasmids in centre of lateral field; C=0.9-1.2.....
.....*hydrophilus* Sher, 1966.

102. Lip region lacking annules or with indistinct annules..... 103.

- Lip region with distinct annules..... 106.

103. Annules on tail terminus distinctly narrower than other tail annules.....*conicephalus* Sher, 1966.

- Annules on tail terminus not narrower than other tail annules.....
.....102.

104. Lip region low, truncate .....*microcephalus* Sher, 1966.

- Lip region high, rounded..... 105.

105. Tail with 5-7 annules ventraly.....
..... *glissus* Thorne & Malek, 1968.

- Tail with 12-13 annules ventraly .....
.....*langicaudatus* Sher, 1966.

106. Tail conspicuously indented terminally..... 107.

- Tail not indented terminally ..... 109.

- Tail indented, ventral projection enveloped in cuticular folds.....*Pteracercus* Singh, 1971.

107. Inner incisures of lateral fields fusing in posterior third of

tail..... *crenacauda* Sher, 1966.

- Inner incisures of lateral fields extend freely up to tail..... ..... 110.

108. Tail terminus with a conspicuous notch up to which extend the incisures..... 108.

- Tail terminus not provided with a notch and the incisures extend freely up to tail ..... *solani* Rashid, 1972.

109. Spear 20-24 microns long..... .....*indenticaudatus* Mulk & Jairajpuri, 1974.

- Spear 26-26 microns long ....*ventroprojectus* Patil &Khan, 1982.

110. Spear knobs anteriorly cupped; phasmids 9 or more annules anterior to anal level.....*delhiensis* Khan & Nanjappa, 1972

- Spear knobs rounded; phasmids 5 annules anterior to anal level..... 111.

111. Spear 20-22 microns long; tail more than twice anal body width long.....112.

- Spear 23 microns or longer; tail more than one but less than twice anal body width long ..... 113.

112. Phasmids 2 annules posterior to 6 annules anterior to anal level; offset spermagonium with sperm..... .....*craigi* Knoblock & Laughlin, 1973

- Phasmids posterior to anal level spermatheca offset with sperms.....*digitatus* Siddiqi & Hussain, 1964.

113. Lip region truncate .....114.

Lip region rounded..... 117.

114. Tail projection elongate and pointed; spear knobs anterior flat.....***egyptiensis*** Tarjan 1964.

- Tail projection short and blunt; spear knobs anteriorly concave.....***tropicus*** Roman, 1965.

115. Body length 0.56-0.68mm; O = 21-25..... .... ***magniferensis*** Elmigly, 1970

- Body length 0.69-0.85 mm; O = 26-44..... 116.

116. Lateral canals present ..... 117.

- Lateral canals absent..... 118.

117. Lateral canals distinct throughtout body; spear 34-38 microns long..... ***canalis*** Sher, 1966.

- Lateral canals distinct near intestine only; spear 31-34 microns long.....***paracanalis*** Sauer & Winoto, 1975

118. Orifice of dorsal oesophageal gland at less than 1/3 the spear length from base of spear..... 119.

- Orifice of dorsal oesophageal gland at more than 1/3 the spear length from base of spear..... .....121.

119. Body annules about 3 microns wide; tail with 6-9 annules ventrally .....***bradys*** Thorne & Malek, 1968.

Body annules about 1.9 microns wide; tail with 9-14 annules ventrally..... 120.

120. Head offset, with 6 annules, labial region completely hemispherical ..... ***paxilli*** Yuen, 1964.

- Head continuous with 4-5 annules, labial region anteriorly truncate..... ***neopaxilli*** Inserra *et. al.*; 1979.

121. Spear less than 30 microns long; males not reported..... ..... 122.

- Spear 31-33 microns long; males present .... ***trivandranus*** Mohandas, 1976

122. Tail projection distinctly annulated with irregular outline ..... 123.

- Tail projection indistinctly annulated usually with a smooth regular outline ..... 124.

123. Phasmids 1-4 annules anterior to anal level; 'O'= 47-50 ..... ***digitiformis*** Ivanova, 1967

- Phasmids more than four annules anterior to anal level; 'O'=32-36..... ***pseudorobustus*** Steiner 1914, Golden, 1956.

124. Spear 26 microns or shorter..... 126.

- Spear 26 microns or longer..... 125.

125. Lip region capped by prominent labial disc..... ..... ***phalerus*** Anderson, 1979.

126. Opening of dorsal oesophageal gland 8-11 microns from base of spear; spear knobs with flattended anterior surface..... 127.

- Opening of dorsal oesophageal gland more posterior; spear knobs rounded..... ***bembasae*** Elmigly, 1970.

127. Phasmids post-anal ..... ***pisi*** Swarup & Sethi, 1968

128. 'O'= less than 50; body length under 0.7mm..... ..... ***flatus*** Roman, 1965.

DESCRIPTION OF TAXA

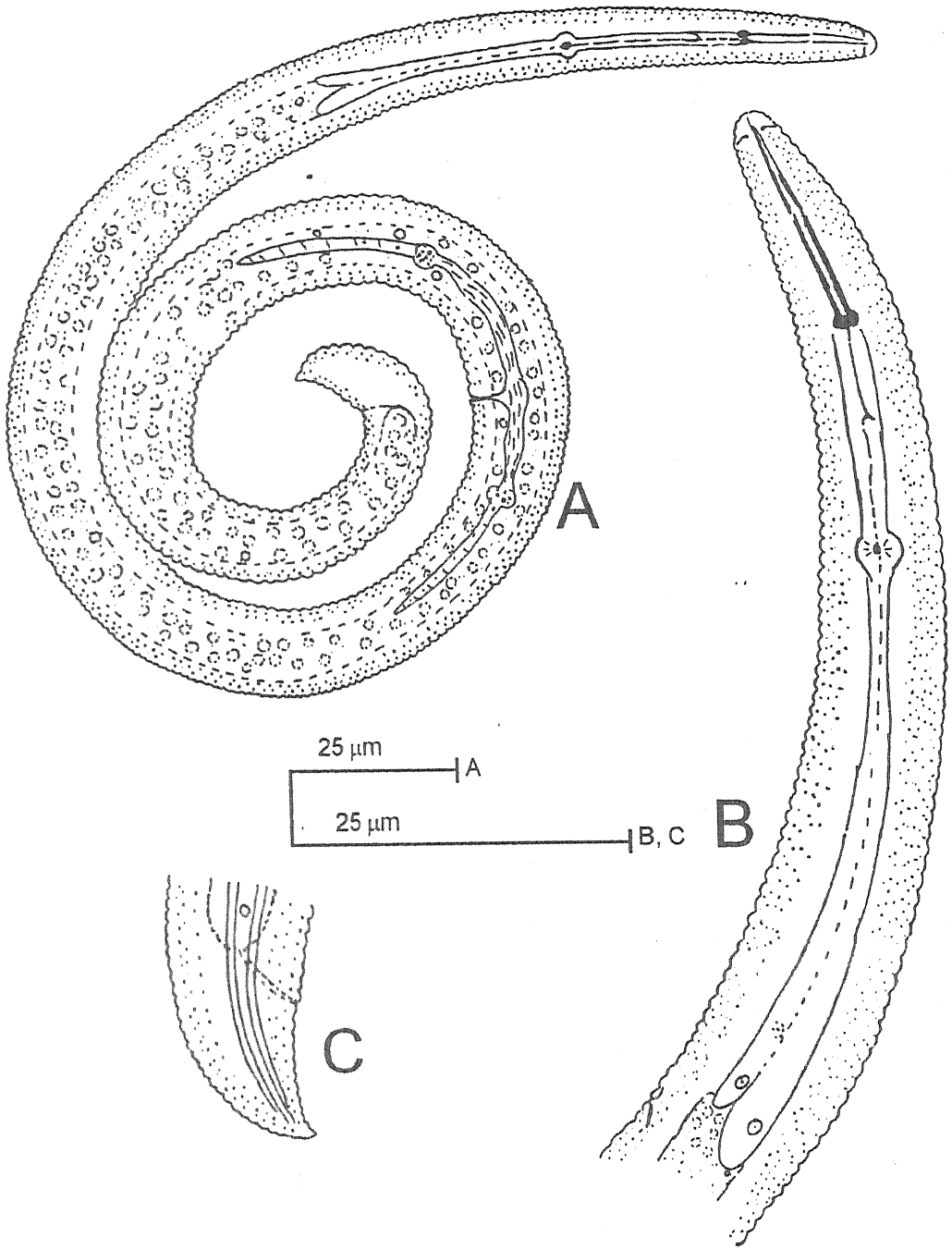

Fig. 2. Helicotylenchus dihystera A-C

Helicotylenchus dihystera (Cobb,1893) Sher,1961

(Fig. 2, A-C)

Measurements

(10 ♀♀) L = .56-.72 mm; a =25-32; b = 5.2-6.2;

b′= 4.2-5.4 ; c = 30 -38; c′= 0.8-1.2;

v = 58-62; spear = 25-28 µm ; m = 44-48;

o = 37-45

Descriptions :

Female :

Body usually in closely spiral shape after fixation. Lip region hemispherical, 4 or 5 often indistinct annules. Spear knobs with indented anterior surface. Excretory pore at level of anterior end of oesophageal glands. Hemizonid just anterior to excretory pore. Hemizonion usually not visible. Spermatheca usually conspicuous offset with out sperm. Phasmids 5 to 11 annules anterior to level of anus. Tail more curved dorsally usually with slight ventral projection.

Male : Not found.

Type habitat and locality :

Soil collected from the different type crops roots as per following mention place

1. Barely (*Hordeum vulgare*) at Babina, and canna Jhansi India.

2. Crysopogan (*Crysopogan*) at Barata and Chirgaon, Jhansi India.

3. Guienea grass (*Panicum maximum*) , Dolicus (*Lablab purpureus*) at Chiplota, Gulara

4. Machuri grass (*Iseilema laxum)* at Baral, Bartheri Jhansi India.

Fig. 3. Helicotylenchus multicinctus A-C

A. Entire female

B. Anterior region of female

C. Posterior region of female

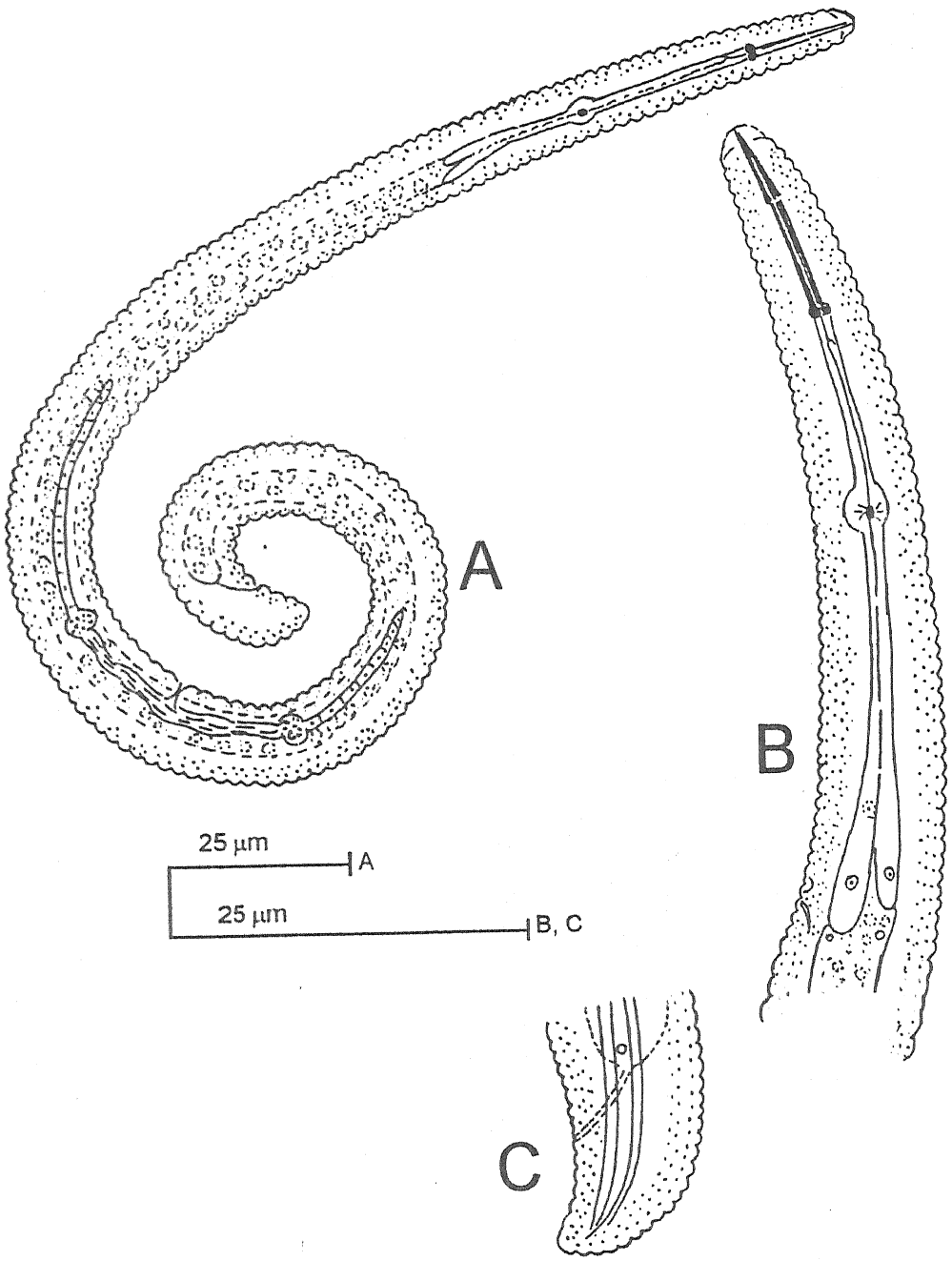

Fig. 3. Helicotylenchus multicinctus A-C

Helicotylenchus multicinctus (Cobb, 1893) Golden, 1956

(Fig 3, A-C)

Measurements :

(10 ♀♀) L= .46 - .52 mm, a = 26-28; b = 4.8-5.2;

b' = 3.2 - 3.8; c = 34-40; c'= 0.8-1.0;

v = 66-68; spear = 22-24 µm; m = 46-50;

o = 25 -30.

Descriptions

Female **:**

Body post portion spiral after fixation Lip region hemispherical with 3 or 4 indistinct annules. Spear knobs rounded, sometimes flattend anteriorly. Excretory pore usually at level of anterior end of oesophageal glands.Hemizonid just anterior to excretory pore. Spermatheca slightly offset, usually filled with sperm Phasmids 2 to 6 annuales anterior to anal level. Tail terminus hemispehrical, 6 to 12 annules.

Male : Not found

Type habitat and locality :

Soil collected from the different type crops roots as per following mention place

1. Cowpea (*Vigna unguiculata)*, at Antheri, Bala ji Jhansi India.
2. Brothriochloa (*Bothriochloa)* at Parichha, Kochha bhawar Jhansi India.

3.Dicanthium (*Dicanthium annulatum)* at Bangri, Pharpura, Jhansi India.

4. Maize (*Zea mays)*, at Digara old Barata, Jhansi India.

5. Lucerne (*Medicago saliva)* at Karguan, Laxman pura., Jhansi India.

6. Dhaman grass (*Cenchrus setigerus)* at Not Ghat, Marora, Moza Phar-pura.

Fig. 4. Helicotylenchus indicus A-C

A. Entire female

B. Anterior region of female

C. Posterior region of female

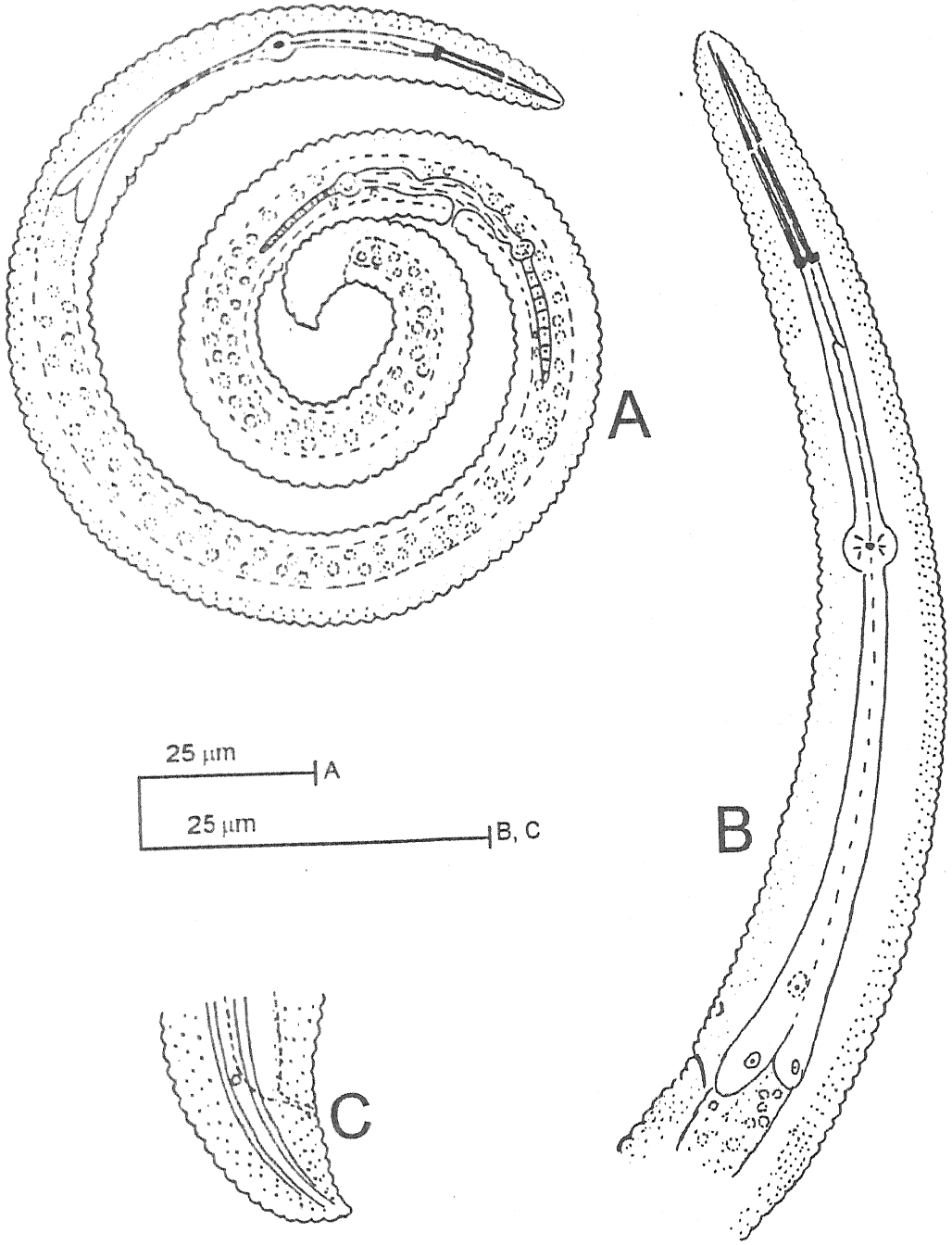

Fig. 4. Helicotylenchus indicus

Helicotylenchus Indicus Siddiqi 1963

(Fig 4, A-C)

Measurements :

(10 ♀♀) L = 0.56-0.64 mm; a = 22-24; b = 4.2-5.6; b′ = 4.2-4.8; c = 41-48; c′ = 0.8-1.0; v = 60-65; spear = 20-33 µm ; m = 42 - 48; o = 24-32.

Descriptions

***Female* :**

Body in closely spiral shape. Lip region truncate, 5or7 indistinct annules. Spear knobs with flattend anterior surface. Spermatheca offset, without sperms. Phasmids 4 to 8 annules anterior to level anus. Tail more curved dorsally, concave hemispherical to slight ventral projection, 9 to 12 annules. Excretory pore 2 annules anterior to the base of oesophageal gland.

Male : Not found.

Type habitat and locality :

Soil collected from the different type crops roots as per following mention place

1. Subabool (*Leucaena lucocephala)* at Jhansi, Bangroli,Jhansi India.
2. Sorghum (*Sorghum bicolor)* at Moth, Phari, Jhansi India.
3. Napier grass (*Pennisetum purpureum)* at Samthar, Moza-Samthar,

Jhansi India.

4. Soyabean (*Glycine max)* at Sujata Mota Rund-kalari Jhansi Inida.

5. Oat (*Avena saliva)* at Paduva Banguva, Jhansi India.

6. Dinanath grass (*Pennisetum Pedicullatum)* at Samthar, Jhansi India.

7. Setaria (*Setaria sphacelata)* at Jhansi, India.

Fig. 5. Helicotylenchus trifolus A-C

A. Entire female

B. Anterior region of female

C. Posterior region of female

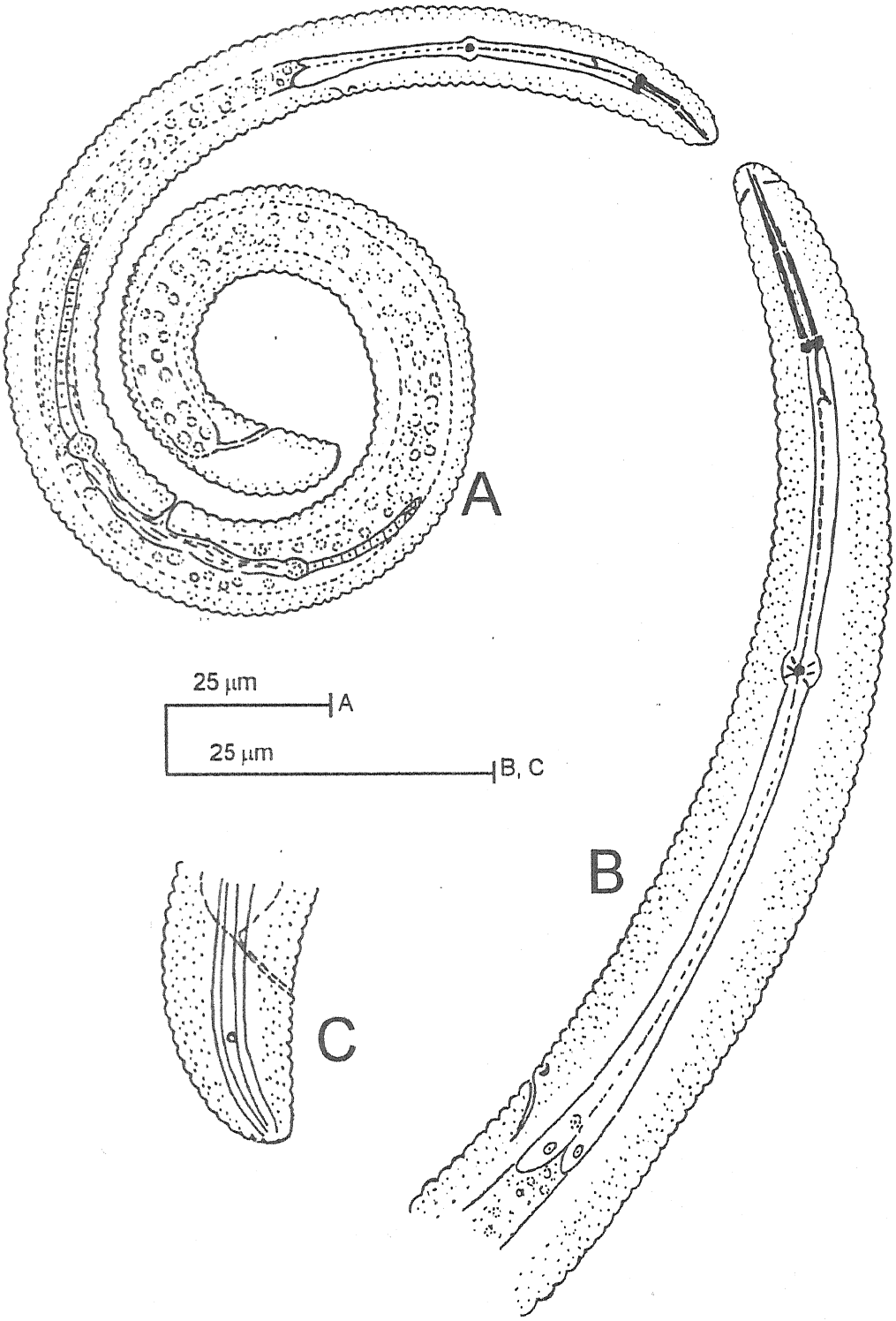

Fig. 5. Helicotylenchus trifolus A-C

Helicotylenchus trifolus n.sp.

(Fig 5, A-C)

Measurements :

Holotype female : L = .55mm ; a = 25; b = 5.2;

b' = 4.2; c= 31; c' = 0.8; v = 65;

spear = 22 µm; m = 46; o =48.

Paratype female: (n = 6) : L = .55-.62 mm ; a =25-30;

b = 5.2-5.8; b' = 4.2-4.8;

c = 31-36; c' = 0.8-1.0; v= 65-67;

spear = 22-24 µm; m=46-48; o = 48-50

Description

Female:

Body spirally coiled after fixations. Lip region rounded with 2-3 indistinct annules. Spear knobs 4 µm across by 2 µm high with flattened anterior surface median oesophageal bulb rounded cephalids not visible. Hemizonid just anterior to the excretory pore. Excretory pore 3 to 4 annules anterior to the base of oesophageal gland. Spermatheca not offset, empty without sperms. Oocytes in single rachis anteriarly atrandom. Tail slightly concave dorsally with blind end. Phasmids 4-5 annules posterior to anus.

Male : Not found

Type habitat and locality :

Soil around roots of Berseem (*Trifolium alexandrinum)* at Baruasagar, Jhansi India.

Type specimens :

Collected by the author in January 1999. The holotype and six paratypes are with the author.

Differential diagnosis :

Helicotylenchus trifolus n.sp.- comes closer to *H.clarkei* sher, 1966 but differs in lip region (truncate in *H.clarkei*) and body size (0.56-0.69 mm in *H.clarkei)* and o (25-38 in *H. clarkei).* It also comes closer to *H. martini* sher, 1966 but differs in lip region, (truncate in *H. martini*) spear knobs (rounded in *H.martini*) and spermatheca (with sperms in *H. martini*).

Fig. 6. Helicotylenchus agrostus A-C

A. Entire female

B. Anterior region of female

C. Posterior region of female

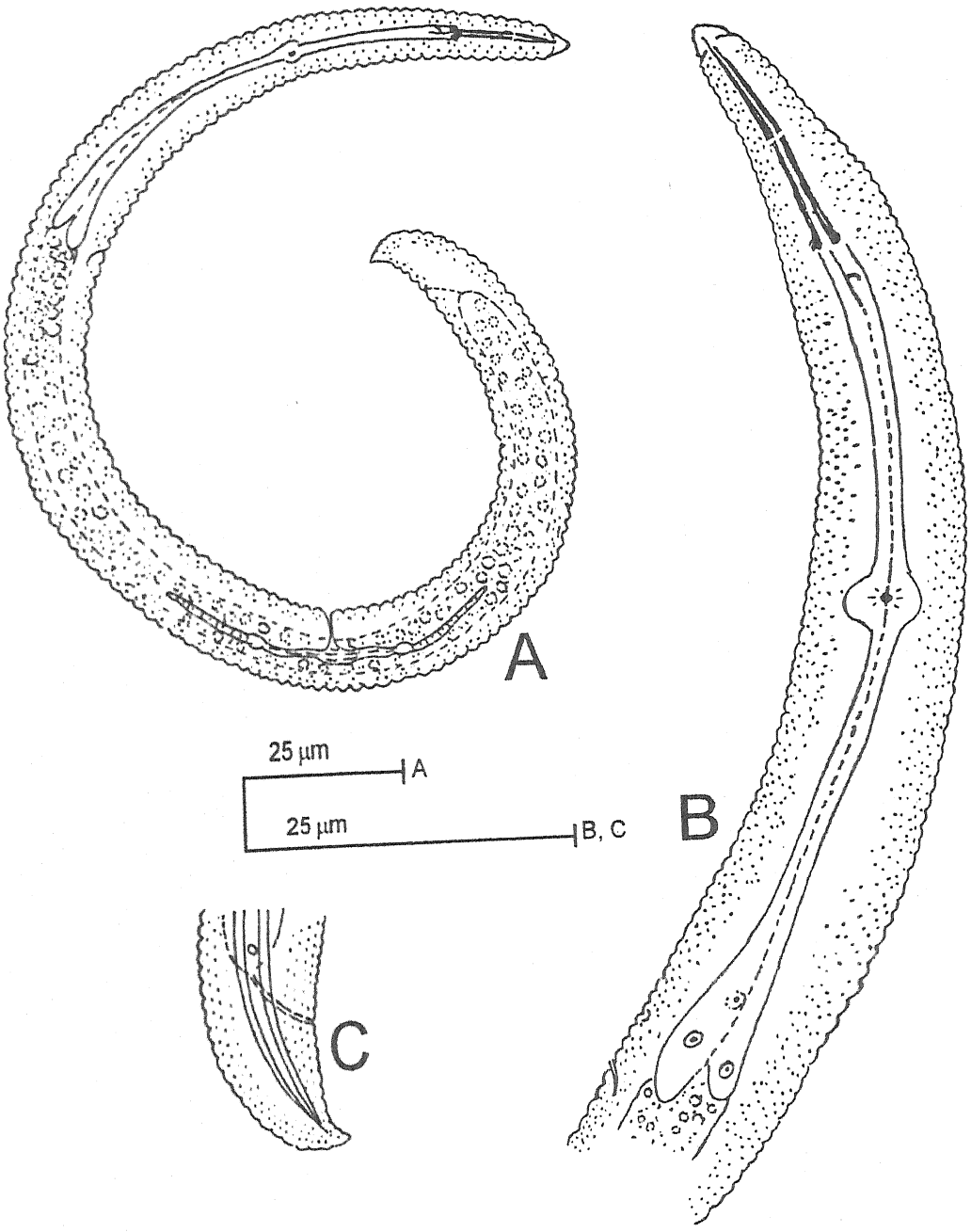

Fig. 6. Helicotylenchus agrostus A-C

Helicotylenchus agrostus n.sp.

(Fig 6, A-C)

Measurements :

Holotype female : L= 0.45mm; a = 25; b = 4.6;

b' = 4.5; c = 30; c' = 0.7; v = 58;

spear = 28 µm; m = 50; o = 22.

Paratype females: (n = 10) : L = 0.45-0.50 mm; a = 25-32; b = 4.6-5.2;

b' = 4.5-5.0; c = 30-32; c' = 0.7-1.0; v = 58-62;

spear = 28-31µm; m = 50-53; o = 22-25.

Descriptions

Female:

Body slightly spiral after fixation, lip region truncate without or with indistinct annules. Spear knobs 3µm across by 2µm high with, slopping anterior surface. Median oesophageal bulb rounded, Cephalids not visible. Hemizonid 4-5 annules anterior to excretory pore. Excretory pore at the anterior end of oesophageal gland. Spermatheca not offset, empty without sperms. Oocyst in single stand. Tail more concave dorsally with slight (less than 2 annules) ventral projection phasmids 5-6 annules anterior to anus.

Male: Not found

Type habitat and locality:

Soil around roots of Bermuda grass (*Cynodon dactylon*)

Type specimens :

Collected by the author in January 1999 holotype and ten paratypes are with the author .

Differential diagnosis :

Helicotylenchus agrostus n.sp comes closer to *H.indicus* siddiqi, 1963 but differs in the lip annules (4-5 in *H.indicus).* Spear length (21-23µm in *H.indicus*). It also comes closer to *H.digonicus* but differs in the shape of spear knobs (slightly indented anteriorly in *H. digonicus*) in body length (.50-.79 in *H. digonicus*) in (26-37 in *H. digonicus*).

DISCUSSION

Discussion

The plant parasitic nematodes are of considerable agricultural importance as pests of crop plants. Microscopic size of plant parisitic nematodes (0.52 to 1.0 mm) causes difficulty in identification of species. No applied or experimental work is possible without correct identity of the species. But Various schemes have been proposed for identification of species of *Helicotylenchus* (ch. for Tuner R. and Wong, Y; 1985); Firoza, K and maqbool, M.A.; 1994) or all practical purpose the present day taxonomy depends almost exclussively or morphology. The morphological character both external and internal, can be studied and recorded with comparative case because of the trasparent bodies of nematodes in live and dead animals, under microscopes.

Plant parasitic nematodes belonging to the genus *Helicotylenchus* are commonly known as spiral nematodes. They assume spiral shape on fixation with gentle heat. They are ecto- or semi-endo parasites of various crops. The main diagnostic characters of this genus are : Lip region without longitudinal striationus. Dorsal oesophageal gland opening usually 1/4 or more of spear length behind the basal knobs of spear. Oesophageal glands are distinct, overlapping the intestine dorsally, laterally and ventrally. The largest overlap

being ventral. Gonads amphidelphic, female tail usually curved dorsally, terminus conoid to hemispherical or mucronate. Phas mids small, near anus.

On the basis of the above diognostic characters Steiner in 1945 proposed the genus *Helicotylenchus* with type species. *H. dihystera* (Cobb, 1893) Sher, 1961. The latest position of the genus *Helicotylenchus* is under the sub family Rotylenchinae of the family Hoplolaimidae. (Golden, 1971)

The first step for the identification of nematodes is an in-depth knowledge of the external as well as internal morphology. So that the various combinations and degree of variations can be recorded.

In the present study a survey of these spiral nematodes belonging to the genus *Helicotylenchus* has been conducted from forage crops grown in and around Jhansi. This survey shows that these nematodes are cosmopoliton in distribution irrespective of crops.

In the world 201 species of spiral nematodes have been described so for among them 16 species are either described or reported from India. Sixteen species have be synonimised fifty nine species are grouped under species inquirendae .

The amended key, proposed for the identification of species of the genus *Helicotylenchus* is based on the most consistent characters like tail shape and tail terminus, spermatheca, lip region, lip annulations, position of orific of dorsal oesophageal glands, position of phasmid in relation to annus. Other characters like, shape of spear knobs, length of spear, body lenght also make reliable combinations for identification. This key covers most specius of *Helicotylenchus* described so far.

In the present survey *H. dihystera* (Cobb, 1893) Sher, 1961, *H. multicinctus* (Cobb, 1893) Golden, 1956, *H. indicus* Siddiqi, 1963 has been re-described and illustrated from the study sights.Two new species have been described from the proposed study sites. *H. trifolus* n. sp. described from the host Berseem (*Trifolium allexandrinum*) has close affinity with *H. clarkei* Sher, 1966, but differs in lip region body size and the position of orific of dorsal oesophageal gland . This new species is also comes closer to *H. martini* Sher, 1966, but differ in lip region shape of spear knobs and spermatheca. *H. agrostus* n.sp. described from Bermuda grass *(Cynodon dactylon)* and comes closer to *H. indicus* Siddiqi, 1963, but differs in lip annules and spear length. It also comes closer to *H. diagonicus* but differs in shape of spear

Discuss what is speciae in your descrip tion

diagonicus but differs in shape of spear knobs, body length and in position of the orific of dorsal oesophageal gland.

The present system of identification accomodate most of the consistant morphological characters and maximum number of *Helicotylenchus* spp. described so far.

SUMMARY

Summary

Nematodes are highly diversified group, they occur in unimaginable numbers in wide variety of shapes, sizes and structures. The plant parisitic nematodes are of considerable agricultural importance as pests of crop plant. They are minute ranging from 0.5 to 0.1 mm although nematodes of different kinds are fairly uniform structurally except for the differences in their cuticular structure lip region, feeding apparatus oesophagus excretory system and reproductive system etc.

Microscopic size of plant parasitic nematodes causes difficulty in identification of species. No applied or experimental work is possible without correct identity of the species for all practical purpose the present day taxonomy depends almost exclusively on morphology.

A nematode can be defined in one sentence as "triploblastic, bilaterally symmetrical, unsegmented pseudocoelomate animal". The nemantodes in general posses elongate, cylindrical or worm-like body, usually unciliated. The body is covered by tough and resistant cuticle secreted by epidermal (hypodermal) cells.

Spiral nematodes (eh. *Helicotylenchus spp.*) are ecto as well as semiendo-parasites of crop plants. The body of spiral nematodes assume spiral when relaxed with gentle heat, it curves ventrally. The shape of spiral formed is also variable.

Helicotylenchus Steiner, 1945 can be diognosed on the characters : lip region without longitudinal striations. Dorsal oesophageal gland opening usually 1/4 or more of spear length behind the basal knobs of spear. Oesophageal gland are distinct, over-lapping the intestine dorsally, laterally and ventrally, the largest overlap being ventral. Gonads amphidelphic female tail usually curved dorsally, terminus conoid to hemispheroid, often mucronate Phasmids small, near anus.

Filipjev (1934) Proposed Hoplolaiminae and the genus *Rotylenchus* and listed only the type species. It was only in 1936 that he provided the diagnosis of the genus *Rotylenchus* there by establishing it in accordance with International Code of Zoological Nomenclature. Filipjev and Schuurmans Stekhoven(1941) expanded the diagnosis of the genus and included under it ten nominal species, all of which except the type have now been transferred to six other

genera of Tylenchida (Baker, 1962).

Steiner (1945) proposed the genus *Helicotylenchus* in the sub family Tylenchinae and distinguished it from *Rotylechus* on the basis of protruding oesophageal gland and pre anal phasmids in the new genus and the oesophageal glands enclosed in terminal bulb and phasmids post anal in *Rotylenchus*.

Thorne (1949) gave an emended diagnosis of Rotylenchus and pointed out that *Tylenchus robustus* de. Man, 1880 did have over lapping oesophageal glands, the character that was used by Steiner to seperate *Helicotylenchus* from *Rotylenchus*. However, he did not synonymise *Helicotylenchus* with *Rotylenchus*. The diagnosis of the subfamily Hoplolaiminae was emended and the following genera were included *Hoplolaimus*. *Rotylenchus* and *Helicotylenchus*.

The body posture of the spiral nemotodes generally assume spiral shapes when relaxed by gentle heating. The curvature of the body is always towards ventral side.

The size of the body of species of *Helicotylenchus* varies from 0.46 to 0.68 mm. The cuticle is secreted by the epidermal cells that are derived from the ectoderm. It is a non-cellular, non living layer

forming the external covering of the nematode. The cuticle on the outer side of the body is called external cuticle and those lining the internal structures as internal cuticle. The cuticle of *Helicotylenchus* is marked with fine striations. There are four incisures in the lateral fields.

The hemizonoid (belt orgirdle) is a highly refractive, biconvex structure forming a semicircle ventrally and ending at the lateral fields. It is present either anterior or posterior to the excretory pore.

The hemizonid is situated along the isthmus between the median bulb and basal glandular portion of the oesophagus.

The phasmids are lateral sense organs, occur in a pair, usually on each side of tail through they are small often insignificant structures. They are of taxonomic importance. The phasmids are sometimes preanal or sometimes postanal. The usual location of phasmids is in the centre of the lateral fields almost at the same latitude on either side of the tail.

The lip region (also called as head) shows many important variations, which may be used either as specific or generic characters. In some nematodes the lip region is completely merged with the body. The shape of lip region is variable, may be truncate,

hemispherical or rounded.

The spear also called as mouth cavity or buccal cavity forms the feeding appratus connecting the mouth with the oesophagus. It is exceedingly variable in shape, size and detailed structure and is considered on extremely valuable and handy character in nematode taxonomy.

The spear is made up to two parts. The anterior part is called chelilostome is formed by an invagination of the external cuticle and is not surrounded by oesophageal tissue. The posterior part formed by the anterior region of oesophagus lies embedded in the oesophageal tissue is termed as oesophagostome. Both these sections of stoma are heavily cuticularized. In *Helicotylenchus* it is a well - developed structure of an anterior conical (metenchium) and a posteriorly cylindrical (telenchium) portions which are clearly demarcated.

Oesophagus is the second and largest part of stomodeum lying between stoma and intestine. Oesophagus typical hapolaimoid type, represented by a procarpus, a median bulb and a basal glandular portion. The distance between the base of oesophageal gland lobe and the oesophageal gland lobe and the oesophago-intestinal junction

is of taxonomic importance.

The intestine opens in to rectum which in turns open out side by a slit called anus.

In many species of *Helicotylenchus* the tail is short bluntly conoid to obtusely rounded. A digitate type of tail is present in some species of *Helicotylenchus*. The size and shape of the tail is variable. It may be dorsally curved and provided with slight ventral projection to hemispherical and smooth. The ventral projection may be pointed or irregularly indented.

The nematodes are dioecious or amphigonus within a species. However, there are only a few species having males and females found in equal proportions. Usually the males and lesser or far lesser than the females or may even be completely absent.

The phenomenon of hermaphoroditism where both sperm and ova are simultaneously produced by different part of the same gonad are common in these nematodes. This phenomenon was reported to occur in species of *Helicotylenchus*, but is doubted by many workers. In parthenogenesis the males are almost completely lacking and the eggs can develop without fertilization.

The male are generally slightly smaller than their females and lie upon death with their posteriors tail curved ventrally because of the strong copulatory musculature. The two sexes can also be easily separated on the basis of their primary and secondary sexual characters.

The reproductive system is composed of two tubular glands which vary in length and may be straight. There are two most of germ cells proliferation.

i. Telogonic : The germ cells are proliferated only at the apical and or tip of the gonad

ii. Hologenic : The germ cells are produced along the entire length of the gonad

The genital tubes are lined with a single layer of epithelium which covers the germ cells and forms the ducts. In males the terminal reproductive duct joins the rectum to form cloaca.

The female nematodes of *Helicotylenchus* spp. possess two sets or branches (didlephic) reproductive organs. The number and the manner of arrangement of sexual branches is considered to be of great taxonomic value. The position of vulva is usually in or near the middle of body. The various stages in the reduction and loss of

middle of body. The various stages in the reduction and loss of gonad can be seen in species of *Helicotlenchus*.

A female sexual branch typically comparises an ovary, oviduct, uterus, vagina and vulva. The ovary is a hollow, elongate tube lined with flattend epithelial cells and contains few to a large number of oocytes. The apical end of ovary has a cap cell at the tip.

The structure number and arrangement of these cells is of fundamental importance in nematode systematics. The uterus is the largest and the most complex part of the reproductive tract and serves the function of fertilization egg shell formation and ejection of egg (egg laying). The upper distal part of the uterus is differentiated in to a sperm storage organ (spermatheca). It keeps the sperms in a viable state. The size and shape (rounded, oval, elongated) of spermathica may differ from species to species or organs to organs and is of some taxonomic importance. It may be axial or non-axial (offset).

The uterus (or uteri) join vagina which is a short, narrow and flattened tube lined with cuticle and provided with well developed musculature(dilator and constrictor vagina).

The egg in nematodes are laid out side the body (oviparous) where the embryonic development takes place (exotoky). However,

sometimes the egg develop within the body of female (endotoky) without being laid.

A survey of the spiral nematoda belonging to the genus *Helicotylenchus* has been conducted from forage crop grown in and around Jhansi. As Disrict Jhansi is situated 25.26 N latitude & 78.35 E longitude in the world map. The following 35 localities as mentioned as under have been covered.

The Soil samples were collected from the most important forage crops : e.g. Anjan grass, Berseem, Barley, Bermuda grass, Bothriochloa, Cowpea, Crysopogan, Dhaman grass (moda), Dicanthium grass (marvel), Dolicus (lab-lab-bean), Guinea grass, Lucerne, Machuri grass, Maize, Napier grass, Oat, Dinanath grass, Setaria, Sorghum (Jowar), Subabool, Soyabean.

So far known, list of nominal species of *Helicotylenchus* in the world (126 specieses) mentioned in the thesis. Out of these, we have found 16 Indian specieses and mentioned in the thesis.

The list of the synonims of the above said species are also listed in the thesis.

A part from it the list of species Inquirendae are also described in the thesis.

The various dimension of the *Helicotylenchus* based on female have been measured according to mentioned key given in the thesis.

In which three of the species were identified i.e.

1. *Helicotylenchus dihystera* (Cobb, 1893) Sher, 1961.
2. *Helicotylenchus multicintus* (Cobb, 1893) Golden, 1956.
3. *Helicotylenchus Indicus* Siddiqi, 1963.

Two entirely new species were described, the details of those are summarised as under :

Helicotylenchus trifolus n.sp.

Measurements:

Holotype female : L = .55 mm; a = 25; b = 5.2;

b' = 4.2; c = 31; c' = .8; v = 65;

spear = 22 um; m = 46; 0 = 48

Paratype female : (n = 6) : L = .55 - .62; a = 25 - 30;

b = 5.2 - 5.8; b' = 4.2 - 4.8;

c = 31- 36; c' = .8 - 1.0; v = 65 - 67;

spear = 22 - 24 um; m = 46 - 48; 0 = 48 - 50

Description

Female :

Body spirally coiled after fixations. Lip region rounded with 2-3 indistinct annules. Spear knobs 4 µm across by 2 µm high with flattened anterior surface median oesophageal bulb rounded cephalids not visible. Hemizonid just anterior to the excretory pore. Excretory pore 3 to 4 annules anterior to the base of oesophageal gland. Spermatheca not offset, empty without sperms. Oocytes in single rachis anteriarly atrandom. Tail slightly concave dorsally with blind end. Phasmids 4-5 annules posterior to anus.

Male : Not found

Type habitat and locality :

Soil around roots of Berseem *(Trifoliium allaxadrium)* at Baruasagar, Jhansi India.

Type specimens :

Collected by the author in January 1999. The holotype and six paratypes are with the author.

Differential diagnosis :

Helicotylenchus trifolus n.sp. - comes closer to *H. clarkei* Sher, 1966 but differs in lip regiion (truncate in *H. clarkei*) and body size (0.56-0.69 mm in *H. clarkei*) and o (25-38 in *H. clarkei*). It also comes closer to *H. martini* Sher, 1966 but differs in lip region, (truncate in *H. martini*) spear knobs (rounded in *H. martini*) and spermtheca (with sperms in *H. martini*).

Helicotylenchus agrotus n.sp.

Measurements :

Holotype female : L = 0.45 mm; a = 25; b = 4.6;

b' = 4.5; c = 30; c' = .7; v = 58;

spear = 28 µm; m = 50; 0 = 22

Paratype female: (n = 10): L = 0.45-.50;a = 25 - 30; b=4.6-5.2

b' = 4.5 - 5.0; c=30-32; c' = 0.7-1.0;v= 58-62

spear = 28-31 µm; m = 46-48; o = 22-25

Description

Female :

Body slightly spiral after fixation, lip region lip region truncate without or with indistinct annules. Spear knobs 3 µm across by 2 µm high with, slopping anterior surface. Median oesophageal bulb rounded, Cephalids not visible. Hemizonid 4-5 annules anterior to excretory pore. Excretory pore at the anterior end of oesophageal gland. Spermatheca not offset, empty without sperms. Oocyst in single stand. Tail more concave dorsally with slight (less than 2 annules) ventral projection phasmids 5-6 annules anterior to anus.

Male **:** Not found

Type habitat and locality:

Soil around roots of Bermuda grass (*Cynondon dactylon*)

Type Specimens:

Collected by the author in January 1999 holotype and ten paratypes are with the author .

Differential diagnosis :

Helicotylenchus agrostus n.sp. comes closer to *H. indicus* Siddiqi, 1963 but differs in the lip annules (4-5 in *H. indicus*). Spear length (21-23 µm in *H. indicus*). It also comes closer to *H. digonicus* but differs in the shape of spear knobs (slightly indented anteriorly in *H. digonicus*) in body length (0.50 to 0.79 in *H. digonicus*) in o (26-37 in *H. digonicus*).

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